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OXIDANT AIR POLLUTANT EFFECTS ON A WESTERN CONIFEROUS FOREST ECOSYSTEM. TASK C. STUDY SITE SELECTION AND ON-SITE COLLECTION OF BACKGROUND INFORMATION

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California University

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February 1973

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Oxidant Air Pollutant Effects on a Western Coniferous Forest Ecosystem

Task C

Study Site Selection and On-Site Collection of Background Information

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February 1973

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Introduction

The San Bernardino National Forest was selected for a study of the impact of oxidant air pollutants because of its proximity to the heavily populated south coast basin of California and because evidence of encroachment of pollutants into the area. Researchers from four campuses of the University of California and the United States Forest Service are cooperating in the project to determine the impact of pollutants on the total ecosystem.

A report for Task B was prepared to present historical information about the San Bernardino National Forest and to identify factors aside from air pollutants which have affected specie distribution, health of organisms and successional development in the forest.

This report for Task C is intended to identify and describe in considerable detail two areas in the San Bernardino Forest selected to represent a reasonable distribution of major forest species and to represent areas exposed to a gradient of pollutants during the past two decades. The current condition of various components of the ecosystem in these selected areas was determined by on-site inspection and monitoring of atmospheric quality during the summer of 1972 by researchers in several disciplines involved in the study.

Section I

General Description of the Study Area

Joe R. McBride

The San Bernardino Mountains have been selected as the principle site for the study of the impact of air pollution on a western mixed conifer forest. The literature concerning these mountains has been reviewed in a manuscript prepared for the Environmental Protection Agency (Protocol Study of the Impact of Oxidant Air Pollutants on a Western Mixed Conifer Forest: Task B).

The purpose of this report is to describe a number of specific locations within the San Bernardino Mountains. These sites were investigated during the summer of 1972. The investigation involved field surveys to obtain background data on the following areas of effort: (1) an understanding of the dominant species in terrestrial plant communities including species diversity and density, age structure, size indication by crown class, seed production, and insect and disease problems; (2) a survey of important insects looking at species composition and density, sex ratio, predator population, and phenology; (3) a knowledge of the important airborne and soil micro-organisms; (4) comparisons of soil types and soil-water relationships; (5) a preliminary comparison of climatic variables within the proposed study areas including temperature, rainfall, material indicators of atmospheric pollutants, light intensity, and evapo-transpiration; (6) determine dominant species diversity and density of wildlife, phenology, age structure, and vigor; and (7) determine the nature of the water shed and the possible interrelations with loss of certain vegetation cover.

To initiate the field study two transects were established in the San Bernardino Mountains (Figure 1). A transect approach was used in order to provide a gradient of both vegetative and air pollution conditions along which the impact of oxidants could be studied. The transects were located along expected gradients of oxidant air pollution. The Lake Arrowhead transect was thought to be a gradient of high to moderate ozone concentration while the Barton Flats transect represent a moderate to low gradient. Initially these ozone gradients were approximated on the basis of tree damage. During the summer field monitoring stations were established to measure ozone concentration along the transects. Results of these measurements will be reported later.

The topography of both transects is mountainous. Elevations range from 3200 to 8095 feet along the Lake Arrowhead transect. The unique topographic feature of this transect is the abrupt slope along the southern boundary of most of the transect. This slope drops down to the San Bernardino valley. As the inversion layer is destroyed almost daily during May - September basin oxidants flow over the transect from its south and southwest boundaries. Above the rim of the slope air movement is influenced by the topography. The Mojave River, Deep Creek, and Grass Valley Creek drainages tend to funnel oxidants north across the transect and into the desert.

The Barton Flat transect is located in general along the Santa Ana River. Elevations along this transect range from 3950 to 8950 feet. The Santa Ana River drainage is the dominant topographic feature of the transect. Oxidant air pollution moves out of the basin either from beneath the inversion or from the eroding edge of the inversion layer with the afternoon up-canyon flow. This general pattern of air movement, up the canyon in the afternoon and back down at night, provides a somewhat more uniform flow of oxidants across the Barton Flats transect than occurs across the Lake Arrowhead transect.

The dominant vegetation type on each transect is the Mixed Yellow Pine-White Fir forest with Black Oak (PF_M Figure 2 and 3). This type is dominated by *Pinus ponderosa*, *P. Jeffreyi*, *P. Lambertiana*, *Libocedrus decurrens*, *Abies concolor*, and *Quercus kelloggii*. Species composition varies somewhat within the type with *Pinus jeffreyi* dominating at the xeric end of the moisture gradient and *Abies concolor* occurring at the mesic end. Various types of chaparral also occur on both transects. Hard chaparral (*Ceanothus leucodermis* dominant with *C. crassifolius*, *Arctostaphylos glauca*, *A. glandulosa*, *Cerocarpus* spp. and scattered *Adenostoma fasciculatum*) being the most common.

Within each large transect two plots, named Dogwood and Barton Flats -- previously established by the U.S. Forest Service for observation of air pollution damage -- were selected for more detailed study (Figure 1). Four additional plots were also selected to insure that study sites would be available where oxidant dosage ranged from low to high. These plots fell within the larger Lake Arrowhead and Barton Flats transects (Figure 1), and served as specific study sites where data collection and field observation took place during the summer of 1972.

A road and highway network provides easy access to nearly all sections within each of the two larger transects. California state highways 18 and 138 cross the Lake Arrowhead transect (Figure 4) while the Barton Flats transect (Figure 5) is traversed by California state highway 38. A detailed description of access to each of the shorter plots is given in Appendix II.

Appendix I. Vegetation Key (Based on Minnich, R. C. et al. 1969. Mapping Montane vegetation in southern California. Tech. Report 3, Status Report 3, USDI, Contract No. 14-08-0001-10674. 40p. 26 plates.)

CHAPARRAL

C_S - *"Soft" Chaparral* Chamise dominant with some *Ceanothus crassifolius*, scattered individuals in *Arctostaphylos* spp. Rhus spp. and *Cercocarpus betuloides*.

C_H - *Hard Chaparral* - *Ceanothus leucodermis* dominant with *C. crassifolius*, *Arctostaphylos glauca*, *A. glandulosa*, *Cercocarpus* spp. and scattered chamise.

C_{SO},CO,C_o - Oak Chaparral - *Quercus dumosa*, lower elevation, north slopes, likely dominant with *Q. chrysolepus* (CW_O) increasingly evident above approximately 3500 feet, north slopes and sometimes with California Bay.

C_{WD} - *Emergent Oak Woodland in Hard Chaparral* scattered or clustered individuals of *Quercus wislizenii* and/or *Q. chrysolepus* in C_H, 4500-5000 feet.

C_{WD}'- *Interior Oak Woodland* *Quercus wislizenii* with no C_H' but with possible mixing of PJ, PF, species, also Mountain mahogany (*Cercocarpus ledifolius*).

$CF_{bs,bs}$ - *Forest enclave in chaparral*. Big cone Douglas-fir dominant (*Pseudotsuga macrocarpa*) Canyon oak dominance variable.

CE_{cp}, $CP,_{cp}$ - *Conifer emergent in chaparral*. Coulter pine dominant (*Pinus coulteri*) mixes with C_{WD}.

DRY FOREST

DF - *Dry forest*. Coulter Pine and Black Oak (*Quercus kelloggii*) of about equal incidence; occasionally there are nearly pure stands of Black Oak. Little undergrowth.

MONTANE CONIFEROUS FOREST

PF - *"Pure" Yellow Pine-White Fir Forest* *Pinus ponderosa*, *P. jeffreyi*, *P. lambertiana*, *Libocedrus decurrens*, *Abies concolor*, - *Juniperus occidentalis* in drier margins.

PF_M- *Mixed Yellow Pine-White Fir Forest with Black Oak*. All the species in PF and *Quercus kelloggii*.

CT - *Timberland Chaparral* *Arctostaphylos patula*, *Ceanothus cordulatus*, *Castanopsis sempervirens*, *Arctostaphylos patula* with scattered trees of the PF and occasionally LP groups.

TF - *Marginal Conifer Forest* basically an ecotone. A mixture between PF species with CF, and occasionally CE tree species.

PINYON - JUNIPER WOODLAND

PJ_D - *"Dense" Western Juniper and Mountain Mahogany prominent Juniperus occidentalus*, *Cerocarpus ledifolius* and scattered Great Basin sage species (*Artimisia tridentata*, *Chrysothamnus nauseosus*).

PJ - *"Pure" Mostly Pinyon Pine with scattered Juniperus californica* or *J. occidentalis*. Also *Cercocarpus ledifolia*, *Artemisia tridentata*, *Chrysothamnus nauseosus*.

PJ_O - *"Open with desert undergrowth*, a few chaparral species in *Arctostaphylos*, *Quercus*; Pinions and Junipers widely scattered.

MISCELLANEOUS

S - SUBCLIMAX VEGETATION
G - GRASSLANDS
M - MEADOWS
B - BARREN
R - RIVERLINE VEGETATION - in the absence of tree species of the prevailing plant grouping, i.e., this vegetation type includes tree or bush species ecologically adapted to stream environments only. Below 4000 feet, either Sycamore (*Plantanus racemosa*) or Cottonwood (*Populus trichocarpa*); 4000 feet to 7000 feet, White Alder (*Alnus rhombifolia*); above 7000 feet, Willow (*Salix*); Fish Creek, Quaking Aspen (*Populus tremuloides*).

Appendix II.

Camp Angeles

From Camp Angeles Ranger Station, follow Forest Service trail signs SW on rough dirt road for 0.3 mile up to a small parking area. Walk up slope 50 yards to transect and look for 5+00 stake, proceed 206° to west end of plot. West end of plot is distinguished by a recently dead 24" ponderosa pine on the up-slope side which leans severely to the south (up-slope). Look for 0+00 stake NW of leaning tree. Tree #1 is PP, 10.5 dbh, 0+4 ft. distance out, right 45 ft.; tree #2 is dead leaning tree; tree #3 is PP, 25.4 dbh, 0+17 ft. out, right 30 ft. Proceed on 26° azimuth to end of plot at 6+80 ft. near stone water tank with metal roof.

Barton Flats

Proceed east on highway 38 from Camp Angeles R. S. 6.4 miles, enter under arch gateway of Boy Scout Camp on left side of road, proceed 100' to chain gate (F. S. gate lock) and follow partial dirt and partial black top road down to meadow (Cienaga Larga). Drive west on south side of meadow along ill-defined road and park. Walk to west end of meadow and look for several large ponderosa pines at west edge of cienega. Tree #1 is PP 48.0 dbh, 0+14 ft. out, 2.5 ft. left. Tree #2 is PP 14.0 dbh, 0+60 out, 16.5 left. Proceed on 270° azimuth to end of plot at 7+50 ft.

Heart Bar

Proceed east on Highway 38 to turnoff for Heart Bar State Park Campground. Turn right and proceed SE 1.3 miles to intersection 1NO2B, continue for 0.2 mile and park on right-hand side of road in the drainage (note 18" dbh pine leaning north on the downstream side of the road (1NO2B). Proceed SE on foot up ill-defined road on upstream side of 1NO2B for about 150-200 yards where numbered trees will be observed on the right. Plot crosses road at 5+00 where metal stake is driven into ground. Turn left on 90° azimuth walk to 0+00. Turn back and proceed on 270° azimuth to west end of plot at 12+65. Tree #1 is JP, 30.2 inches dbh, 0+4 ft. out, 2 ft. right, #101 JP, 5.0 inch dbh, 0+8.5 ft. out, right 18 ft.

Sand Canyon

Leave highway 38 at sign for Greenspot (ESE of Big Bear Lake), proceed west on dirt road for 0.4 mile to a road fork, bear right. Continue 0.2 mile more to second fork and take Sand Canyon Road, proceed 1.4 miles more to intersection (poorly defined), turn left uphill. Proceed 0.8 mile to fork, bear right; proceed 0.3 mile more to second fork. Park at second fork, walk up left fork 100 yards to trees 30, 31. Stake at base of 31 is 5+00. Proceed uphill on 90° azimuth to beginning of plot or 0+00. Tree #1 is JP 14.7 inches dbh, 0+12 ft. out, 27 ft. left; tree #2 is JP 0+8 ft. out, 49 ft. left. Proceed on 270° azimuth to west end of plot at 11+73 ft.

Snow Valley

About 250 yards west of Snow Valley Ski Lodge, turn north from highway 18 on dirt road to summer home tract. At 0.1 mile up road, (or immediately) bear right at road fork. Proceed 0.1 mile further to intersection with small green metal water tank just uphill (north), turn left. After approximately 0.3 mile, stop at road washout. Walk SW on road toward fallen tree across road. Continue to next drainage and look for tags on trees. Ski trail from Green Valley Lake comes down west side of this drainage and is marked by orange triangles nailed to trees. Tree #1 is JP 30.1 inches dbh, 0+15 ft. out, 1 ft. right; tree #2 is JP 34.5 inches dbh, 0+15 ft. out and 10 ft. left. Plot is bisected by drainage. Proceed on 300° azimuth to end of plot at 9+00 ft.

Crest Park (Dogwood)

At Crest Park, turn from Highway 18 to Rim of the World Drive. Proceed 0.1 mile and take left downhill on Meadow Brook Road. Continue 0.2 mile to Arrowhead Lutheran Camp, turn right, continue on blacktop road until it turns to dirt (dead snag is on right side of road). Park on right (east). Walk due east to small clearing 100 ft. from PP #55 (dbh 30") which is near parking place. At east edge of clearing about 99 ft. east of tree #55, the first tree, PP #101, dbh 4.0 inches is 0+00 distance out and right 1.5 ft.; tree #102 is black oak, dbh 4.0 inches, 0+7.5 ft. out and 36.5 left. First tagged tree is #58, PP, 26.0 inches dbh, 0+56.5 ft. out, right 16 ft. Proceed on 270° azimuth to end of plot at 5+50 ft.

Notes on Tagged Trees: (1x2-3/4 inch numbered aluminum tags)

Plot	Numbers on Tagged Trees	Year Tagged
Dogwood	55 to 100	1968
Snow Valley	1 to 98	1972
Sand Canyon	1 to 70	1972
Camp Angeles	1 to 85	1972
Barton Flats	1 to 50	1968
Heart Bar	1 to 70	1972

Many untagged trees are being observed as well in each plot; these trees are located by distance out and offset (right or left) only and are designated by 101, 102, etc. or 1001, 1002.

FIGURE I. LOCATION MAP

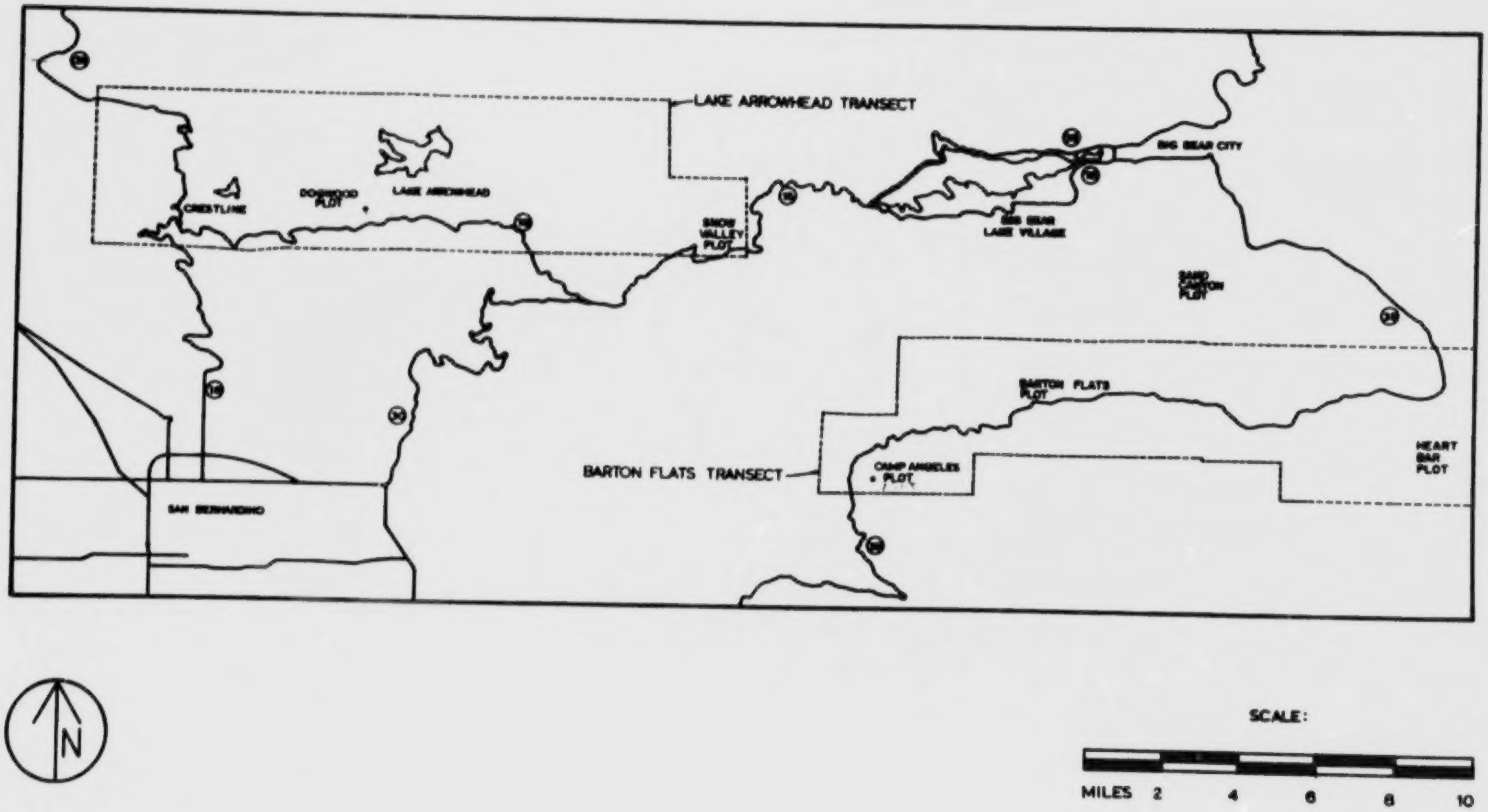
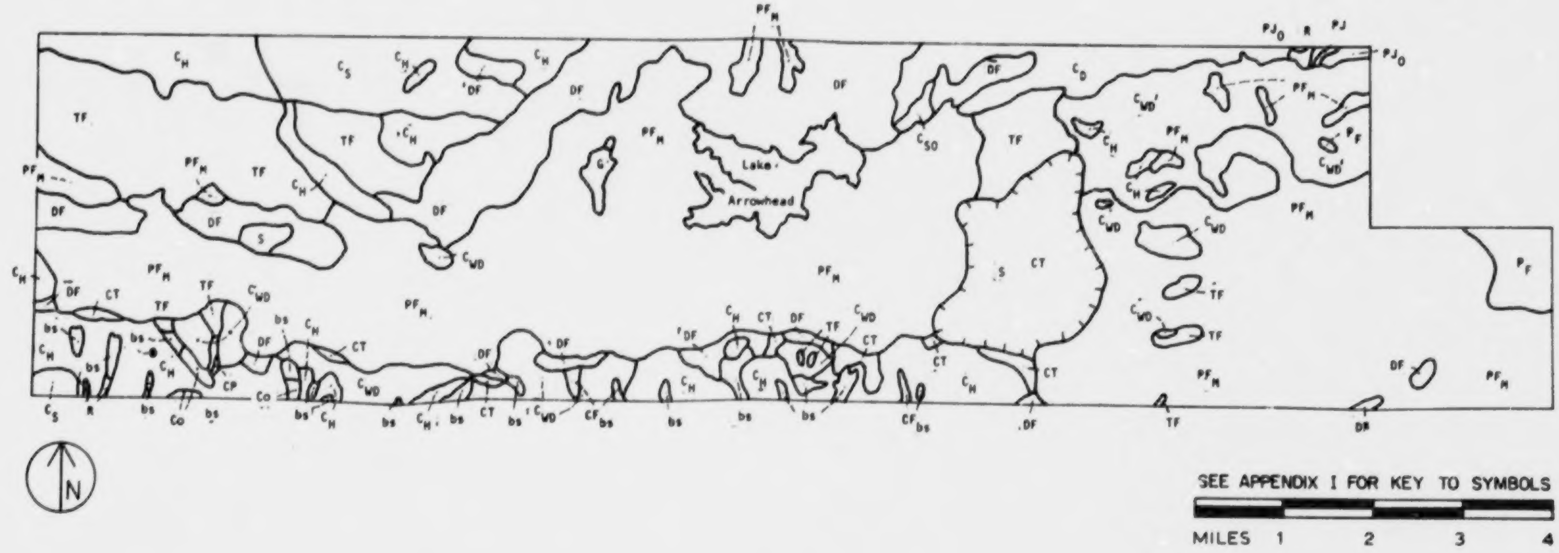

LAKE ARROWHEAD TRANSECT
CRESTLINE
DOGWOOD PLOT
LAKE ARROWHEAD
SNOW VALLEY PLOT
BIG BEAR LAKE VILLAGE
BIG BEAR CITY
SAND CANYON PLOT
BARTON FLATS PLOT
HEART BAR PLOT
BARTON FLATS TRANSECT
CAMP ANGELES PLOT
SAN BERNARDINO
N
SCALE:
MILES 2 4 6 8 10

FIGURE 2. LAKE ARROWHEAD TRANSECT

VEGETATION MAP


Lake Arrowhead
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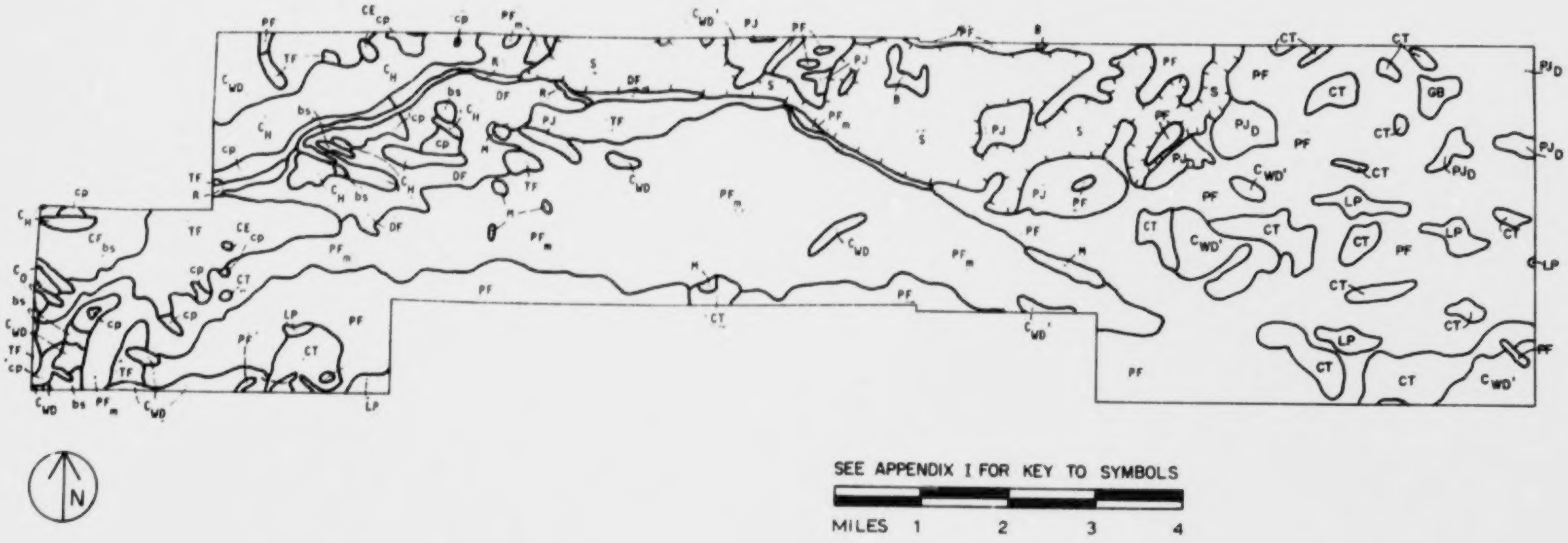
MILES 1 2 3 4

SEE APPENDIX I FOR KEY TO SYMBOLS

FIGURE 3. BARTON FLATS TRANSECT

VEGETATION MAP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SEE APPENDIX I FOR KEY TO SYMBOLS

FIGURE 4. LAKE ARROWHEAD TRANSECT

BASE MAP

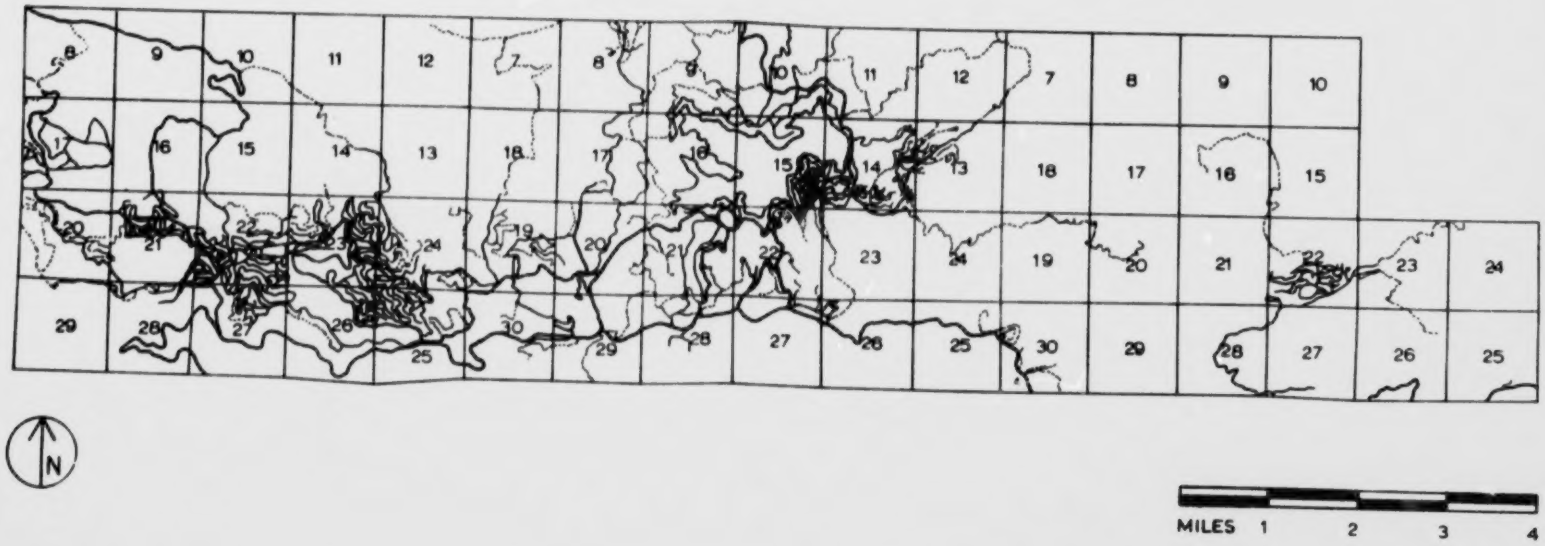
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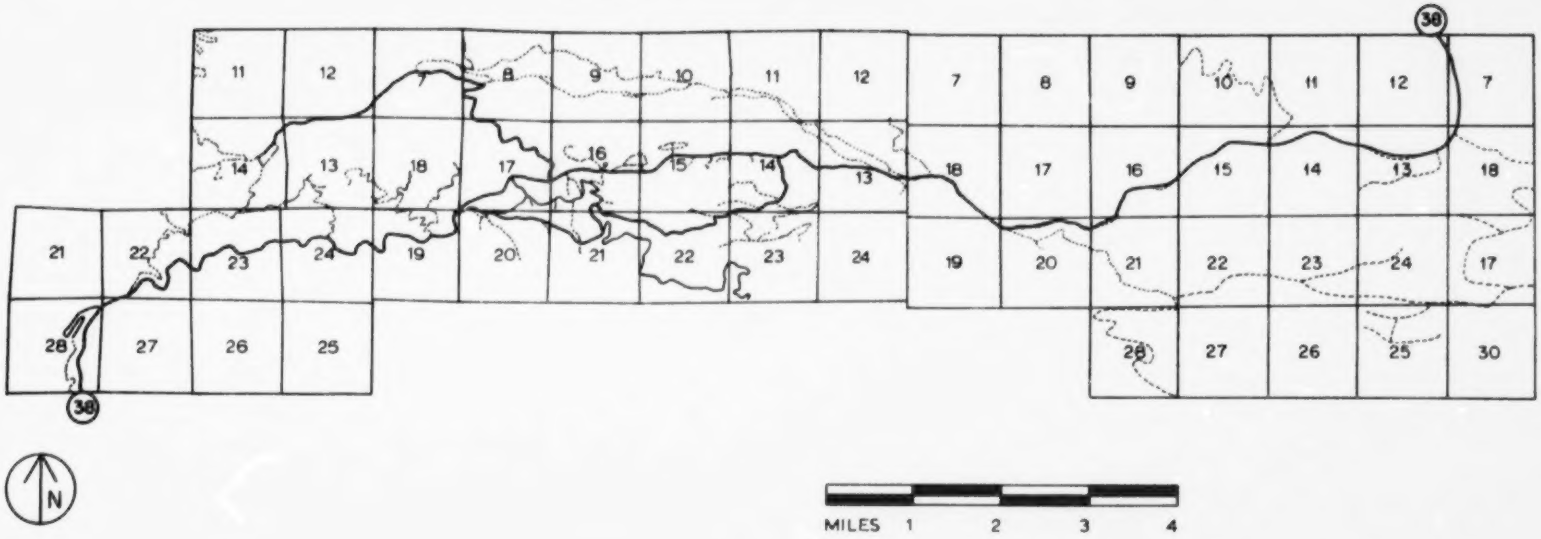
FIGURE 5.   BARTON FLATS TRANSECT

BASE MAP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MILES 1 2 3 4

Section II

Vegetation of Principal Study Sites in the San Bernardino Mountains

Joe R. McBride

Acknowledgments

The following assisted in data gathering and preparation of the report: Dr. Paul R. Miller, William Perkins, Larry Greenwood, and Oscar Clarke.

Introduction

The vegetation of the San Bernardino Mountains is made up of a mosaic of vegetative types that reflect both environmental gradients and man's impact on the land. Vegetative types range from desert brushlands to mesic coniferous forests. Minnich et al. (1969) have classified and mapped the types in the study area. Their work, reviewed in an historical background report on the San Bernardino Mountains (Miller and McBride, 1973) served as a basis for the analysis of vegetation conducted during the summer. Initially their maps were used to produce vegetation type maps for the Lake Arrowhead and Barton Flats transects. These maps indicate that forests dominated by *Pinus ponderosa* and *P. Jeffreyi* occur extensively on both transects. The Montane Coniferous Forest classification unit by Minnich et al., in which *Pinus ponderosa* and *P. Jeffreyi* occur, was established on the basis of imagery on color infrared photography (1:25,000). With this particular photography one cannot readily distinguish the species composition of many coniferous forest stands. Since the Montane Coniferous Forest varies considerably in species composition a detailed description of stands in the study area was needed. Resources were not available to classify and map all stands on the Lake Arrowhead and Barton Flats transects during the summer of 1972. Resources were, therefore, directed toward a detailed examination of vegetation on the six plots. The objectives of this examination were to determine (1) the species diversity, density, and dominance, (2) age structure, (3) stratification, and (4) seed production.

Methods

Species diversity, density, and dominance of trees and shrubs were calculated from measurements taken on each of the six plots. On each plot the location and diameter of all trees over 4 inches diameter breat height (d.b.h.) was recorded. Shrub species were mapped on a sub-plot 20 feet wide located down the center of each plot. These 20 feet wide plots ran the length of each transect. The area covered by each shrub species was then measured off of the sub-plot. All herbaceous species on each plot were collected for the preparation of species lists. All plants were not in flower at the time of collection and many could, therefore, only be identified to genus.

The age structure of the stand of trees on each plot was based on ring counts on cores taken from all trees over 2 inches in diameter occurring on the 20 feet wide sub-plot. These trees and shrubs were plotted on profile diagrams which give an indication of stratification on each plot.

Seed production was estimated on the basis of cones present on the conifer species. Cone counts were made in September and October on each plot. The number of fruits on non-coniferous species were noted in the survey.

Results

The data collected from field surveys has been organized into a series of tables, graphs, maps, and profile diagrams which are useful in making comparisons among the six plots. However, a more general description of each plot will be developed in the following paragraphs before comparisons are made among the plots.

Dogwood Plot

The Dogwood plot is dominated by Pinus ponderosa which comprises about 70 percent of the basal area. (Table 1). Libocedrus decurrens, Quercus Kelloggii, Pinus Lambertiana, and Abies concolor also occur on the plot. The measured basal area of these species amounts to 107.3 square feet per acre. This figure is somewhat lower than thebasal area of the forest surrounding the plot due to the presence of roads and trails on the Dogwood plot (Figure 1). Pinus ponderosa and Q. Kelloggii are evenly distributed over the plot. Libocedrus decurrens is clumped primarily in the first 100 feet of the plot.

The trees on the plot are arranged in three general strata (Figure 7). The upper strata is dominated by a few old P. ponderosa trees which are probably residual trees from logging operations of the 19th century. A few old L. decurrens also occur in this strata. Beneath these old veterans is a layer of younger P. ponderosa and L. decurrens which averages 40 to 60 feet in height. This layer forms the dominant canopy of the forest. The lowest tree strata is dominated by Q. Kelloggii, L. decurrens, and A. concolor. This strata is below 30 feet in height which is probably a maximum height for the Q. Kelloggii. The conifers in this lowest strata are for the most part young slower growing tolerant species. These can be expected to grow beyond the present limits of this lower strata.

Brush species were not encountered on the Dogwood plot. High tree density may preclude their survival or establishment in the forest understory. The herbaceous plants on the plot occurred in low density. These herb layer species are listed in Table 4.

Age distribution of trees on the Dogwood plot is shown in Figure 13. This data suggests that events around the turn of the century set the stage for establishment of tree seedlings. Pinus ponderosa and L. decurrens became established at that time and continued to successfully establish seedlings for the next 40 years. Subsequent to the 1930's the establishment of P. ponderosa has declined. Establishment of L. decurrens continued to increase until about 1960, since then no successful regeneration of L. decurrens has taken place. Establishment of Q. Kelloggii has occurred during the last 60 years with a very rapid increase in the last 30 years. The large number of Q. Kelloggii seedlings in the 0-9 year age class suggests this species may eventually dominate the plot, assuming the decrease in conifer regeneration is to continue. No seed production (Table 5) was observed on the Dogwood plot in 1972. A similar lack of seed production was noted in 1971 .

Snow Valley

Pinus Jeffreyi is the dominant tree on the Snow Valley plot (Table 1). Approximately 35 P. Jeffreyi trees/acre occur on this plot. This density is nearly double that of Q. Kelloggii the next most important species on the plot. Other trees found on the Snow Valley plot are P. Lambertiana, L. decurrens and A. concolor. The tree density on this plot averages about 90 trees per acre. The basal area of trees amounts to approximately 203 square feet per acre.

The plot is dissected by a creek along which most of the L. decurrens are found (Figure 2). Q. Kelloggii occur more commonly toward the upstream portion of the plot but are not found immediately along side the creek. Pinus Jeffreyi is uniformly distributed over the plot. A. concolor is found primarily on the northeast facing slope above the creek. At the upper end of the plot A. concolor occurs at the base of the southwest facing slope near the creek. At this location the southwest facing slope is very steep and the base of the slope is protected from insolation in the late afternoon. Pinus Lambertiana occurs in a random pattern in the upper half of the plot.

Five brush species occur on the plot (Table 2). Of these Ceanothus leucodermis and Arctostaphylos Parryana var. pinetorum were located and mapped on the 20 feet wide sub-plot (Figure 2). Ceanothus leucodermis covered approximately 9 percent of this sub-plot while A. Parryana var. pinetorum covered about 4 percent (Table 3). The herbaceous flora of the plot could be distinguished into two groups of species. Along the creek occurred a group of species adapted to the high soil moisture conditions of the spring and early summer. Potentilla glandulara, Utrica Serra, and Zauschneria californica laetifolia were characteristic of these riperian species. Above the riperian zone, on the more xeric slopes, the herbaceous flora was represented by drought tolerant species such as Achillea Millefolium, Anaphylis margaritaceae, and Sitanion Hystrix (Table 4). In both environments the density of herbaceous plants was very low.

The trees on the Snow Valley plot can be grouped into two strata as seen in Figure 8. Pinus Jeffreyi dominates the upper strata which reaches an average height of 130 feet. The lower tree strata is composed of Q. Kelloggii, L. decurrens, and A. concolor. The conifers in this lower strata may be considered as transients. The shrub layer on the plot reaches to a height of about 6 feet. The layer is discontinuous but does dominate the ground surface to the exclusion of most herbaceous plants where it occurs.

Two species of willow, Salix lasiandra var. Abramsii and S. Scouleriana, occur in patches along the creek. A few individuals were over 4 inches in diameter and were treated as trees (Figure 2). Most of the willows were of brush dimension; however, none of these fell within the 20 feet wide sub-plot. It is estimated that the brush sized willows would cover about 3 percent of the plot.

The pattern of age distribution on the Snow Valley plot suggest a long history of sporadic establishment of *P. Jeffreyi* over the past 400 years. (Figure 14) Establishment of this dominant species on the plot appears to have reoccurred at intervals of 80 to 100 years. This may represent the coincidence of fires which prepared the seed bed, good seed years, and a favorable precipitation pattern. The last 150 years have been characterized by the successful establishment of *L. decurrens*, *A. concolor*, and *Q. Kelloggii*. The latter two of these have shown an increased number of seedlings established since 1930. *Quercus Kelloggii* seedlings are especially numerous which suggests the potential dominance of this species on the Snow Valley plot.

Cone production was extremely low in 1972. Only four cones were observed on *P. Jeffreyi* and five cones on *P. Lambertiana*. Nine *Q. Kelloggii* trees were producing acorns (Table 5).

Sand Canyon Plot

The Sand Canyon plot is dominated by *P. Jeffreyi* and *Cercocarpus ledifolius* (Table 1). The *P. Jeffreyi* occurs in an upper tree strata which reaches over 100 feet in height (Figure 9). *Abies concolor* and *Juniperus occidentalis* also occur in this strata. A lower tree strata dominated by *C. ledifolius* is found on the plot. Tree density in both strata is low amounting to only about 46 trees per acre. At this density a closed forest canopy does not occur except where trees are clumped on the plot (Figure 3). The low tree density and the presence of *C. ledifolius* and *J. occidentalis* are indicators of the xeric conditions of the Sand Canyon plot.

Fifteen per cent of the plot is covered by brush species (Table 2). The species making up this cover include *Arctostaphylos Parryana pinetorum*, *Ceanothus leucodermis*, *Chrysothamnus nauseosus*, and *Ribes nevadense*. *Cercocarpus ledifolius* plants under 6 feet in height were also classified and mapped as brush on the plot. Brush density varies over the plot with heavy patches occurring toward the upper end (Figure 3). A list of herbaceous species found on the Sand Canyon plot is shown in Table 4.

An examination of the age distribution of the coniferous species on Sand Canyon plot suggests a pattern of continuous tree replacement (Figure 15). The periodic successful establishment of a few individuals of *P. Jeffreyi*, *A. concolor*, and *J. occidentalis* have lead to a balanced all-age stand. The situation with *C. ledifolius* is somewhat different. In this species there is an abundance of younger age classes, especially the 0-9 and 10-19 age classes. This may indicate an improvement in conditions for seedling establishment of *C. ledifolius* in recent in recent times. The abundance of *C. ledifolius* seedlings impresses the observer with the species potential for dominating the plot.

Cone and seed production on the Sand Canyon plot was exceedingly low in 1972 (Table 5).

Camp Angeles Plot

The Camp Angeles plot is dominated by Pinus ponderosa. This species makes up 53% of the number of trees on the plot and about one half of the basal area (Table 1). The second most important tree is Abies concolor which accounts for 28% of the trees and about 12% of the basal area. Pinus Lambertiana and Quercus Kelloggii also occur on the Camp Angeles plot.

Tree density is uniform over the plot with a total density of about 85 trees per acre. The conifer species are evenly distributed while the Q. Kelloggii show a tendency toward clumping on the plot (Figure 4).

The trees on the Camp Angeles plot can be divided into two layers on the basis of height (Figure 10). An upper strata of conifers occurs over a lower strata of Q. Kelloggii. A few younger conifers are found in this lower strata. Beneath the tree layers is a discontinuous strata of shrubs composed of Amorpha californica and Arctostaphylos Pringlei drupacea. The herbaceous species occurring on the Camp Angeles plot are listed on Table 4.

The age distribution of P. ponderosa suggests a relatively continuous establishment of this species on the plot (Figure 16). Abies concolor and Q. Kelloggii show increased establishment during the past 50 years. The large number of Q. Kelloggii seedlings may be very significant to the balance of species dominance in the future on the Camp Angeles plot.

Cone and seed production were nil on the Camp Angeles plot during 1972 (Table 5).

Barton Flats Plot

The Barton Flats plot is dominated by Pinus ponderosa and P. Jeffreyi (Table 1). On the basis of tree number about 55 per cent of the stand is

P. ponderosa and 34 per cent is P. Jeffreyi. These two species are not uniformly distributed over the plot, but occur in relatively distinct groups. The P. ponderosa is found at the beginning of the plot on a northeast facing slope and at the end of the plot on nearly level ground (Figure 5). Pinus Jeffreyi occurs on the southwest facing slope in the plot. Two oak species (Quercus Kelloggii and Q. Wislizenii) also are present on the Barton Flats plot. These oaks have a basal area of 28.51 square feet which is about 19% of the total basal area of the plot. The Q. Kelloggii is primarily found on the northeast facing slope with the P. ponderosa while the Q. Wislizenii occurs only on the southwest facing slope.

The structure of the tree cover on the Barton Flats plot is characterized by three different strata. The highest strata is made up of very old pines which reach a height of 140 to 160 feet. Trees in this strata are widely separated and do not exhibit crown closure (Figure 11). A middle tree strata occurs on the plot and is composed primarily of P. ponderosa and Q. Kelloggii. The average height of this layer is 80 feet. The lowest tree strata is dominated by P. Jeffreyi but also contains the Q. Wislizenii. This strata is restricted to the southwest facing slope. It averages only 30 feet in height. The pines in this lowest strata will no doubt grow beyond their present height but the Q. Wislizenii is not expected to grow much taller.

Two shrub species, Amorpha californica and Ribes montigenum, occur on the Barton Flats plot. No individuals of these species were located on the 20 feet side sub-plot. It is estimated that they covered less than one percent of the area of the entire plot. An extensive area of Pteriduim aquilinum lanuginosum is located near the west end of the plot. Plants of this species are about 1-3 feet high and form a dense cover. Their distribution has been mapped on the 20 feet wide sub-plot (Figure 5). Other herbaceous species found on the Barton Flats transect are listed in Table 4. Each end of the plot borders on an open meadow. Herbaceous species common to the meadow environment were found in the forest at each end of the plot. These included Koeleria cristata, Capsella Bursa-pastoris, Verbascum Thapsus, and Poa rupicola. Away from the ends of the plot the normal low density montane forest herbaceous flora was found.

Quercus Kelloggii exhibits an age class distribution on the Barton Flats transect that is normally associated with climax forest species (Figure 17). Numerous seedlings and saplings are available to move into openings which may occur in the forest canopy. In contrast, the pines seem past the point of maximum establishment. They will require some event, such as logging or fire, to open the crown canopy and prepare seedbeds for further establishment.

Cone and seed production was extremely low on the Barton Flats plot in both 1971 and 1972 (Table 5).

Heart Bar Plot

The Heart Bar plot was situated further to the east than the other five plots. In this location the environment is more xeric. This xeric condition is reflected in the low tree density (59.6 trees/acre) and low basal area (66.13 square feet per acre) of the forest stand. The stand is (Figure 6) dominated by P. Jeffreyi which has a basal area of nearly 51 square feet per acre. Pinus Jeffreyi trees make up 87.8 percent of the total number of trees on the plot (Table 1). Pinus Lambertiana, A. Concolor, and C. ledifolius are also present on the Heart Bar plot.

The open character of the forest on the plot makes the identification of strata somewhat academic. Layers can be identified, but they seldom are encountered in the superimposed manner one normally associates with stratification of forest stands. Figure 12 illustrates this problem.

Brush is common on the Heart Bar plot. Large patches of *Ceanothus leucodermis* and *Arctostaphylos Parryana pinetorum* occur over much of the plot (Table 3). Scattered individual *Chrysothamnus nauseosus* and *Cercocarpus ledifolius* plants are also common. Less common species are *Amorpha californica* and *Salix Scouleriana*. Approximately 20 percent of the area of the plot is dominated by shrubs.

Herbaceous plants are widely scattered on the Heart Bar plot. Their density is quite low and only a few species are represented (Table 4).

An analysis of the age distribution of trees on the Heart Bar plot suggests a rather continuous addition of trees over the past 160 years (Figure 18). Curves characteristic of climax or sub-climax species are not evident.

Seed production on the Heart Bar plot exceeded that of the other five plots in 1972. Eighteen *P. Jeffreyi* and eight *A. concolor* trees produced cones (Table 5).

Conclusions

The material brought together in this report demonstrates the variation in vegetation which exists along the gradients of oxidant air pollution selected for study in the San Bernardino Mountains. This oxidant gradient parallels a moisture gradient along which forest types have segregated out. Variations in age structure as well as species composition and density occur along these gradients. This variation poses a problem for research in the area. The experimental approach, in which the investigator uses a control for comparative purposes, may not be applicable to this area. It may be necessary to search further for another smog free control area, or to adapt a non-experimental approach to determining the impact of oxidant air pollution on the vegetation of the San Bernardino Mountains. A survey approach which would follow mortality of the various components of the vegetation over time may prove the most applicable method. This could be supplemented by greenhouse and growth chamber observations of injury from ozone. With these observations and a picture of current age structure of various forest stands, one could predict in a specific way the future condition of the forest. In order to develop this capacity the following sorts of investigations should be initiated.

1. A determination of stand composition and age structure for those forest stands in which _P_. _ponderosa_ and/or _P_. _Jeffreyi_ dominate.
2. Monitoring of plant mortality on an expanded series of permanent plots.
3. Studies to measure the relative physiological potential of the major trees and shrubs to withstand oxidant air pollution at various stages of their life cycles.

4. An identification of those environmental factors which are most closely correlated with the normal pattern of seed production, seedling establishment, and tree growth.

Literature Cited

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2. Minnich, R. C., L. W. Bowden, and R. W. Pease, 1969. Mapping montane vegetation in southern California. Tech. Report 3, Status Report 3, USDI, Contract No. 14-08-0001-10674. 40p. 26 plates.

Table 1: Tree layer species composition, density, and basal area

Species	Plot #	Dogwood	Snow Valley	Sand Canyon	Camp Angeles	Barton Flats	Heart's Bar
Pinus ponderosa	# trees*	85	0	0	70	139	0
	spp. comp.**	60.7			53.0	55.9	
	density***	68.0			44.8	80.8	
	basal area	69.41			114.33	73.39	
Pinus lambertiana	# trees	3	13	0	5	0	2
	spp. comp.	2.2	7.0		3.8		1.2
	density	2.4	6.3		3.2		0.7
	basal area	.90	30.56		32.16		1.24
Libocedrus decurrens	# trees	29	28	0	0	0	0
	spp. comp.	20.7	15.0				
	density	23.2	13.6				
	basal area	19.81	46.10				
Abies concolor	# trees	8	32	18	37	0	18
	spp. comp.	5.7	17.2	14.4	28.0		10.4
	density	6.4	15.5	6.7	23.7		6.2
	basal area	1.75	12.98	16.82	38.90		13.93
Quercus kelloggii	# trees	1.5	40	0	20	16	0
	spp. comp.	10.7	21.5		15.2	6.4	
	density	12.0	19.4		12.8	9.3	
	basal area	15.63	9.87		34.77	26.07	
Pinus jeffreyi	# trees	0	73	61	0	86	152
	spp. comp.		39.3	48.8		34.5	87.8
	density		35.4	22.7		50.0	52.4
	basal area		103.60	66.93		44.40	50.91
Juniperus occidentalis	# trees	0	0	3	0	0	0
	spp. comp.			2.4			
	density			1.1			
	basal area			5.46			
Cercocarpus ledifolius	# trees	0	0	43	0	0	1
	spp. comp.			34.4			0.6
	density			16.0			0.3
	basal area			9.55			0.05
Quercus wislizenii	# trees	0	0	0	0	8	0
	spp. comp.					3.2	
	density					4.7	
	basal area					2.44	
TOTAL	# trees	140	186	125	132	249	173
	spp. comp.	100.0	100.0	100.0	1100.0	100.0	100.0
	density	112.0	90.2	46.5	84.5	144.8	59.6
	basal area	107.30	203.11	98.76	220.16	146.30	66.13

* trees over 4" DMH

** spp. composition given in $^0/_0$

*** density given on # trees/acre

**** basal area given in ft^2/acre

Table 2. Shrub species occurring on transects

Species	Dogwood	Snow Valley	Sand Canyon	Camp Angeles	Barton Flats	Heart Bar
Amorpha californica				x	x	x
Arctostaphylos Parryana pinetorum		x	x			x
Arctostaphylos Pringlei drupacea				x		
Ceanothus cordulatus		x				
Ceanothus leucodermis		x	x			x
Cercocarpus ledifolius			x			x
Chrysothamnus nauseosus			x			x
Ribes montigenum					x	
Ribes nevadense			x			
Salix lasiandra Abramsii		x				
Salix Scouleriana		x				x

Table 3.
Brush layer species area covered, per cent cover, and relative per cent cover

Species	Plot #	Dogwood	Snow Valley	Sand Canyon	Camp Angeles	Barton Flat	Heart's Bar
Amorpha californica	area covered*				5564.1	45.1	400.9
	% cover				12.8	0.1	0.9
	rel. % cover**				96.6	100.0	4.3
Ceanothus leucodermis	area covered		4100.7	2304.8			2939.7
	% cover		9.4	5.3			6.7
	rel. % cover		70.8	33.9			31.4
Arctostaphylos parryana var. *pinetorum*	area covered		1693.0	2333.6			4730.2
	% cover		3.9	5.4			10.8
	rel. % cover		29.2	34.3			50.6
Chrysothamnus nauseosus	area covered			57.6			1069.0
	% cover			0.1			2.4
	rel. % cover			0.9			11.4
*Willow******	area covered				198.7		187.1
	% cover				0.4		0.4
	rel. % cover				3.4		2.0
Cercocarpus ledifolius	area covered			749.1			26.7
	% cover			1.7			0.1
	rel. % cover			11.0			0.3
Ribes nevadense	area covered			1354.1			
	% cover			3.1			
	rel. % cover			19.9			
TOTAL	area covered	0	5793.7	6799.2	5762.8	45.1	9353.6
	% cover		13.3	15.6	13.2	0.1	21.5
	rel. % cover		100.0	100.0	100.0	100.0	100.0

* area covered given in ft ^{2}/acre

** relative per cent coverage

*** *Salix lasiandra* on the Camp Angeles transect; *Salix Scouleriana* on the Heart's Bar transect

Table 4. Herb layer species

Species	Dogwood	Snow Valley	Sand Canyon	Camp Angeles	Barton Flats	Heart Bar
Achillea Millefolium		x			x	
Agrostis sp. ?		x				
Amorpha fruticosa					x	x
Anaphalis margaritacea	x	x		x	x	
Arabis sp. ?		x		x	x	
Artemisia Dracunculus			x		x	x
Artemisia ludoviciana					x	x
Asclepias eriocarpa				x		
Barbarea americana		x	x			
Bromus carinatus	x			x	x	
Bromus tectorum					x	
Capsella Bursa-pastoris					x	
Cardamine Breweri					x	
Carex brevipes		x			x	
Carex fracta		x	x			
Castilleja Martinii		x	x			x
Caulanthus amplexicaulis		x				
Chaenactis santolinoides			x			
Chrysothamnus Parryi						x
Convolvulus fulcratus		x			x	
Cordylanthus sp. ?				x		
Corethrogyne filaginifolia	x		x	x		x
Cryptantha sp. ?		x				
Danthonia sp. ?		x				
Elymus sp.				x		
Equisetum arvense					x	
Erigeron sp. ?						x
Erigeron foliosus	x				x	
Eriogonum Kennedyi austromontanum						x
Eriogonum molestum	x					
Eriogonum Parishii			x			
Eriogonum umbellatum bahiaeforme				x		x
Eriogonum umbellatum polyanthum	x		x	x		x
Eriophyllum confertiflorum		x				x
Erysimum capitatum	x	x	x	x	x	
Euphorbia Palmeri						x
Galium sp. ?			x			x
Galium bifolium					x	
Gayophytum diffusum	x	x	x	x	x	
Gilia splendens	x					
Gutierrezia californica			x			x
Hypericum sp. ?		x				
Iris Hartwegii australis	x			x	x	
Juncus obtusatus			x			
Koeleria cristata	x		x		x	x
Lathyrus laetifolius					x	
Linanthus breviculus						x
Linanthus Nuttallii					x	
Linanthus parviflorus croceus	x	x				

Table 4. Herb layer species (cont.)

Species	Dogwood	Snow Valley	Sand Canyon	Camp Angeles	Barton Flats	Heart Bar
Lotus excubitus	x					
Lotus grandiflorus		x		x		
Lotus Heermannii	x	x		x	x	
Lotus oblongifolius		x		x		
Madia sp. ?	x			x		
Monardella lanceolata	x					
Monardella viridis saxicola			x			x
Oenanthe californica			x			
Orthocarpus densiflorus gracilis					x	
Penstemon Grinnellii		x	x	x		
Penstemon labrosus		x	x	x	x	
Poa rupicola					x	
Potentilla sp. ?		x				x
Potentilla glandulosa		x			x	
Pteridium aquilinum lanuginosum	x	x		x	x	
Pyrola picta		x				
Scutellaria Austinae	x	x			x	
Silene sp. ?			x		x	x
Sisymbrium altissimum					x	
Sitanion Hystrix	x	x	x	x	x	
Solidago sp. ?			x			
Solidago californica	x			x	x	x
Solidago occidentalis			x			
Stephanomeria virgata				x		
Taraxacum vulgare	x					
Tetradymia (comosa) ?			x			x
Thalictrum Fendleri		x				
Urtica Serra		x				
Vicia californica					x	
Zauschneria californica latifolia		x		x		

Table 5
Cone and acorn production-1972

Species	Dogwood	Snow Valley	Sand Canyon	Camp Angeles	Barton Flats	Heart Bar
Pinus ponderosa	0/82*	0	0	1/68	2/129	0
Pinus lambertiana	0/3	2/13	0	0/5	0/83	0/2
Libocedrus decurrens	0/28	0/29	0	0	0	0
Abies concolor	0/8	0/31	0/17**	0/37	0	8/18**
Quercus Kelloggii	0/15	9/39	0	2/19	1/14	0
Pinus jeffreyi	0	4/74	2/60	0	0	10/104

* $\frac{\text{Number of trees having any cones (acorns)}}{\text{total number of trees of a species}}$

** Male cones often present with or without female cones

FIG. 2. SNOW VALLEY PLOT — 900 FEET

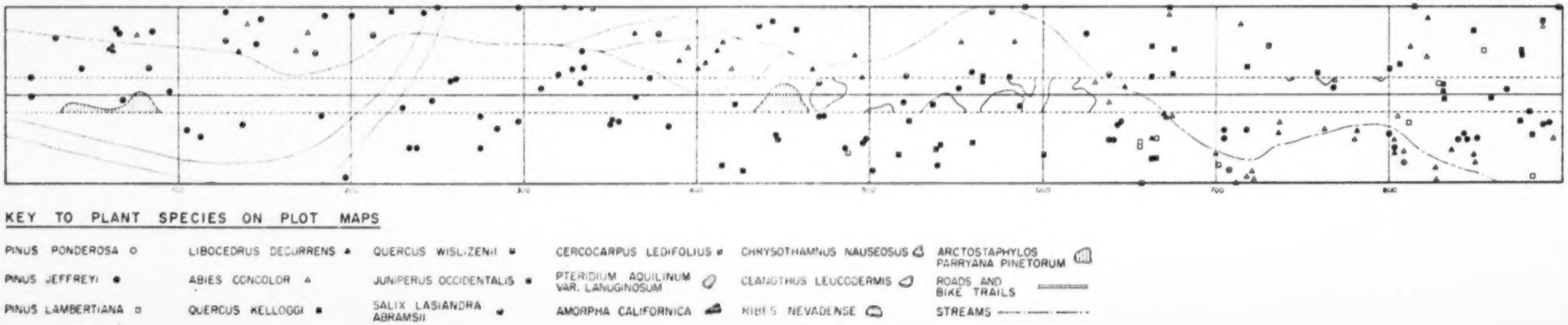
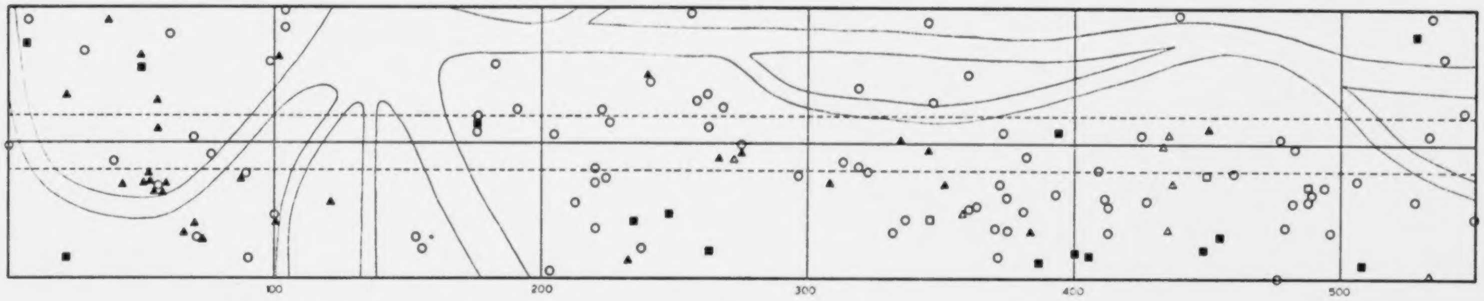

100
200
300
400
500
600
700
800
KEY TO PLANT SPECIES ON PLOT MAPS
PINUS PONDEROSA ○
PINUS JEFFREYI ●
PINUS LAMBERTIANA ▫
LIBOCEDRUS DECURRENS ▲
ABIES CONCOLOR △
QUERCUS KELLOGGI ■
QUERCUS WISLIZENII ■
JUNIPERUS OCCIDENTALIS ■
SALIX LASIANDRA ABRAMSII
CERCOCARPUS LEDIFOLIUS
PTERIDIUM AQUILINUM VAR. LANUGINOSUM
AMORPHA CALIFORNICA
CHRYSOTHAMNUS NAUSEOSUS
CEANOTHUS LEUCODERMIS
RIBES NEVADENSE
ARCTOSTAPHYLOS PARRYANA PINETORUM
ROADS AND BIKE TRAILS
STREAMS

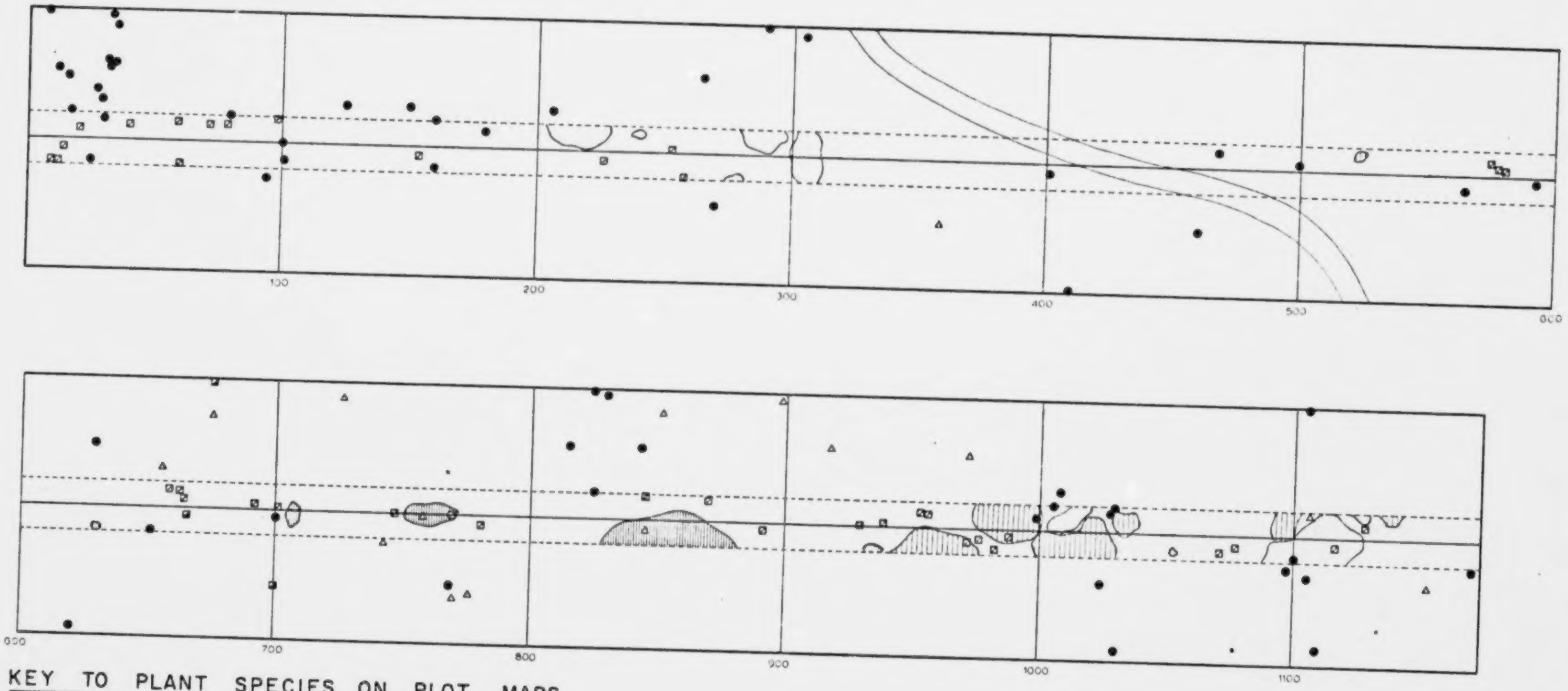
FIG. 1. DOGWOOD PLOT — 550 FEET



KEY TO PLANT SPECIES ON PLOT MAPS

PINUS PONDEROSA ○
PINUS JEFFREYI ●
PINUS LAMBERTIANA □
LIBOCEDRUS DECURRENS ▲
ABIES CONCOLOR △
QUERCUS KELLOGGI ■
QUERCUS WISLIZENII ▣
JUNIPERUS OCCIDENTALIS ■
SALIX LASIANDRA ABRAMSII ◉
CERCOCARPUS LEDIFOLIUS ▣
PTERIDIUM AQUILINUM VAR. LANUGINOSUM ▨
AMORPHA CALIFORNICA ◢
CHRYSOTHAMNUS NAUSEOSUS △
CEANOTHUS LEUCODERMIS ◁
RIBES NEVADENSE ▭
ARCTOSTAPHYLOS PARRYANA PINETORUM ▥
ROADS AND BIKE TRAILS ═
STREAMS —·—·—

FIG. 3. SAND CANYON PLOT — 1173 FEET



KEY TO PLANT SPECIES ON PLOT MAPS

PINUS PONDEROSA ○
PINUS JEFFREYI ●
PINUS LAMBERTIANA □

LIBOCEDRUS DECURRENS ▲
ABIES CONCOLOR △
QUERCUS KELLOGGI ■

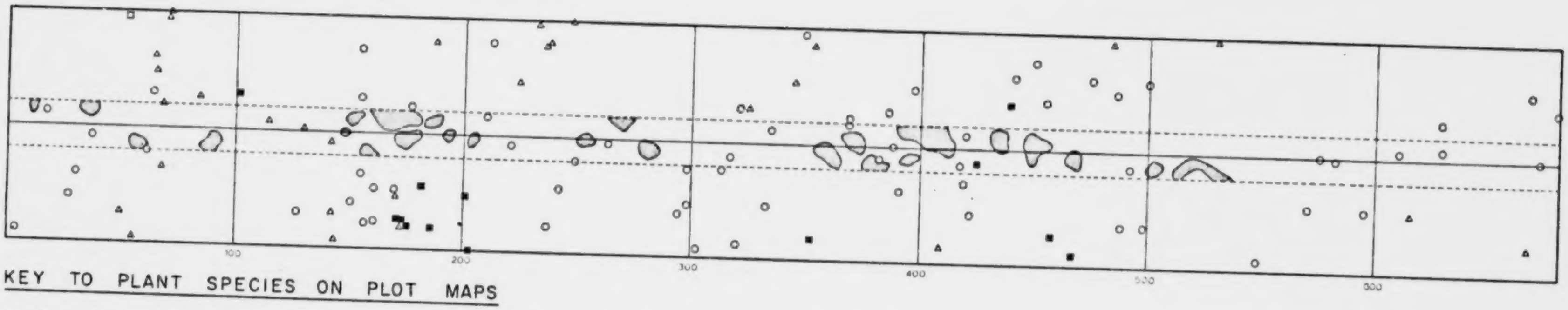
QUERCUS WISLIZENII ⊡
JUNIPERUS OCCIDENTALIS ⊡
SALIX LASIANDRA ABRAMSII ◉

CERCOCARPUS LEDIFOLIUS ⊡
PTERIDIUM AQUILINUM VAR. LANUGINOSUM ▨
AMORPHA CALIFORNICA ▨

CHRYSOTHAMNUS NAUSEOSUS △
CEANOTHUS LEUCODERMIS ○
RIBES NEVADENSE ○

ARCTOSTAPHYLOS PARRYANA PINETORUM ▥
ROADS AND BIKE TRAILS ═
STREAMS —·—·—

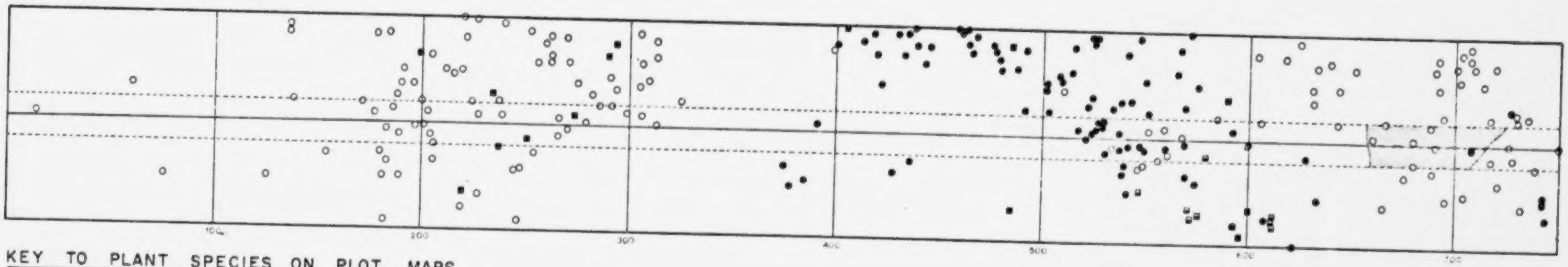
FIG. 4. CAMP ANGELES PLOT — 680 FEET



KEY TO PLANT SPECIES ON PLOT MAPS

PINUS PONDEROSA ○
PINUS JEFFREYI ●
PINUS LAMBERTIANA □
LIBOCEDRUS DECURRENS ▲
ABIES CONCOLOR △
QUERCUS KELLOGGI ■
QUERCUS WISLIZENII ▣
JUNIPERUS OCCIDENTALIS ■
SALIX LASIANDRA ABRAMSII ◉
CERCOCARPUS LEDIFOLIUS ▣
PTERIDIUM AQUILINUM VAR. LANUGINOSUM ▨
AMORPHA CALIFORNICA ▲
CHRYSOTHAMNUS NAUSEOSUS △
CEANOTHUS LEUCODERMIS ◁
RIBES NEVADENSE ▭
ARCTOSTAPHYLOS PARRYANA PINETORUM ▥
ROADS AND BIKE TRAILS ═══
STREAMS —·—·—·—

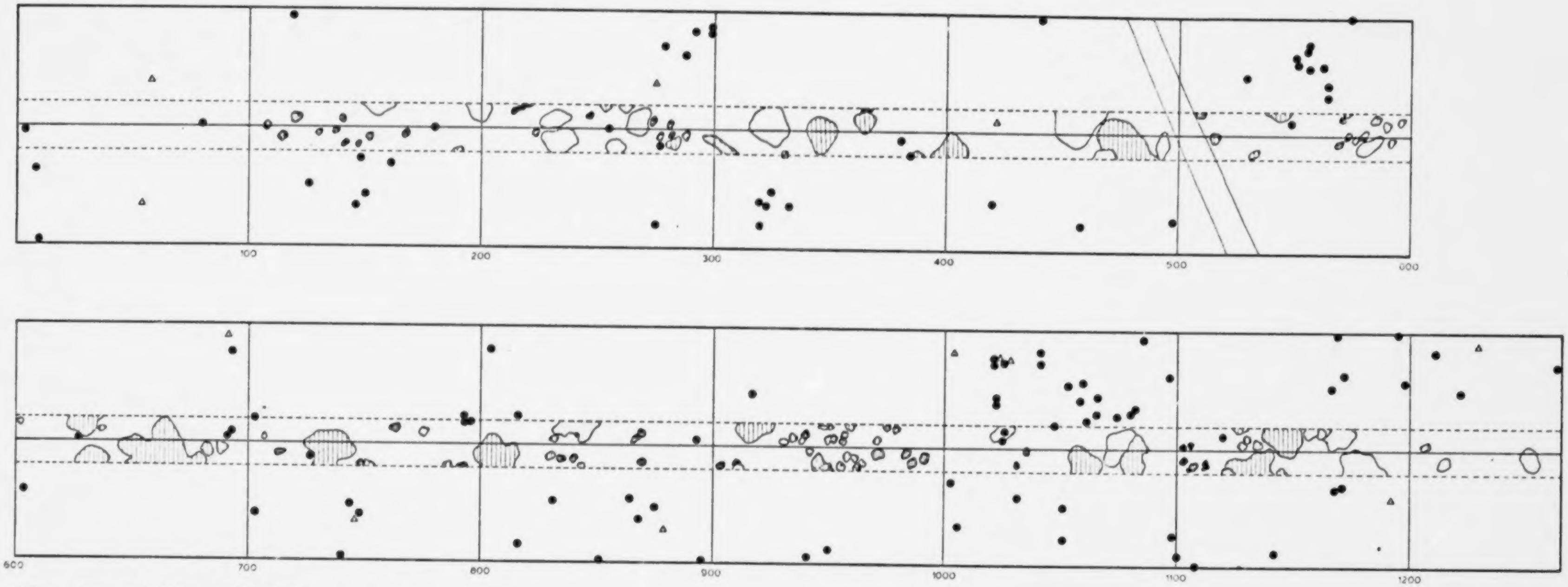
FIG. 5. BARTON FLATS PLOT — 750 FEET



KEY TO PLANT SPECIES ON PLOT MAPS

PINUS PONDEROSA ○
PINUS JEFFREYI ●
PINUS LAMBERTIANA ▫
LIBOCEDRUS DECURRENS ▲
ABIES CONCOLOR △
QUERCUS KELLOGGI ■
QUERCUS WISLIZENII ▪
JUNIPERUS OCCIDENTALIS ▪
SALIX LASIANDRA ABRAMSII ●
CERCOCARPUS LEDIFOLIUS ▪
PTERIDIUM AQUILINUM VAR. LANUGINOSUM ⬭
AMORPHA CALIFORNICA ◆
CHRYSOTHAMNUS NAUSEOSUS △
CEANOTHUS LEUCODERMIS ◇
RIBES NEVADENSE ⬭
ARCTOSTAPHYLOS PARRYANA PINETORUM ▥
ROADS AND BIKE TRAILS ═
STREAMS —·—·—

FIG. 6. HEART BAR PLOT — 1265 FEET



KEY TO PLANT SPECIES ON PLOT MAPS

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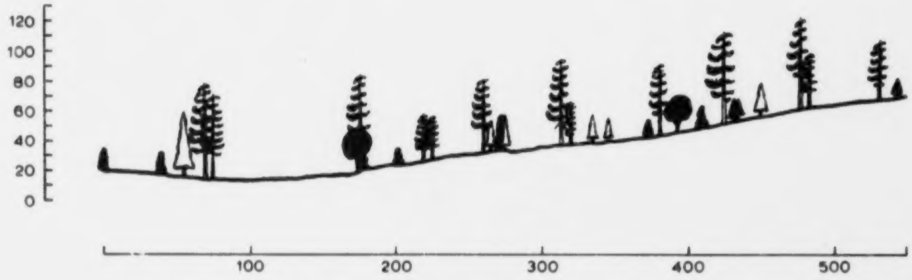
PINUS LAMBERTIANA ▫
LIBOCEDRUS DECURRENS ▲
ABIES CONCOLOR △
QUERCUS KELLOGGI ■
QUERCUS WISLIZENII ▪
JUNIPERUS OCCIDENTALIS ▪
SALIX LASIANDRA ABRAMSII ◒
CERCOCARPUS LEDIFOLIUS ▪
PTERIDIUM AQUILINUM VAR. LANUGINOSUM ▨
AMORPHA CALIFORNICA ▲
CHRYSOTHAMNUS NAUSEOSUS △
CEANOTHUS LEUCODERMIS ○
RIBES NEVADENSE ○
ARCTOSTAPHYLOS PARRYANA PINETORUM ▥
ROADS AND BIKE TRAILS ═
STREAMS —·—·—

FIG. 7. DOGWOOD PLOT - 550 FEET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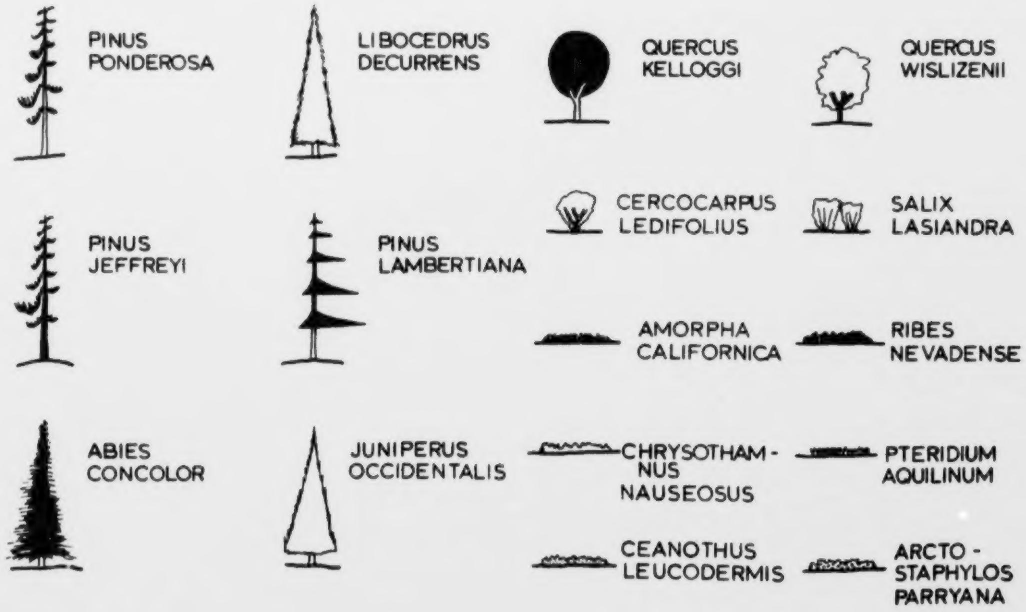
KEY TO TREES AND SHRUBS ON PROFILE MAPS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RIBES NEVADENSE
ABIES CONCOLOR
JUNIPERUS OCCIDENTALIS
CHRYSOTHAM-NUS NAUSEOSUS
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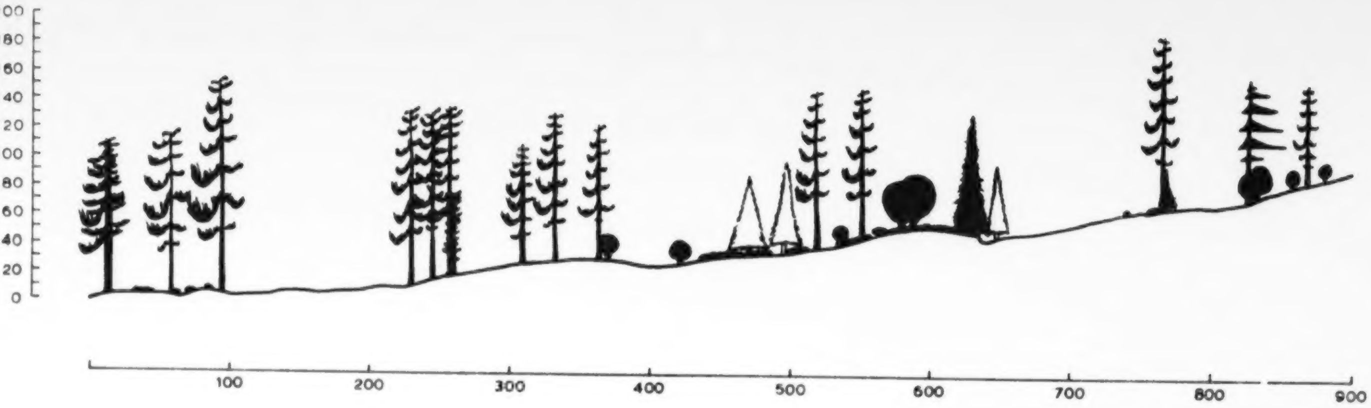
CEANOTHUS LEUCODERMIS
ARCTO-STAPHYLOS PARRYANA

FIG.8. SNOW VALLEY PLOT — 900 FEET



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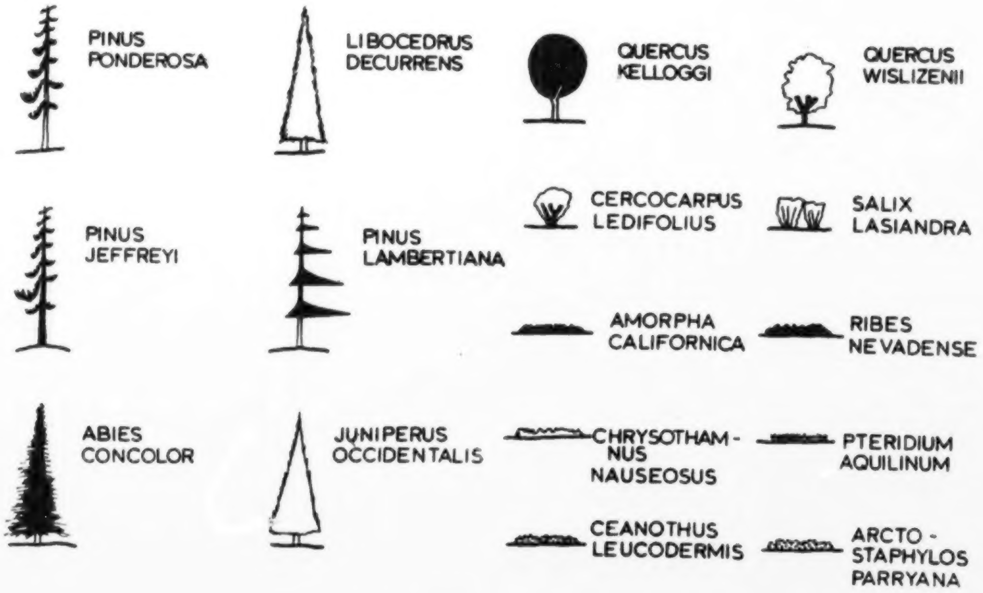
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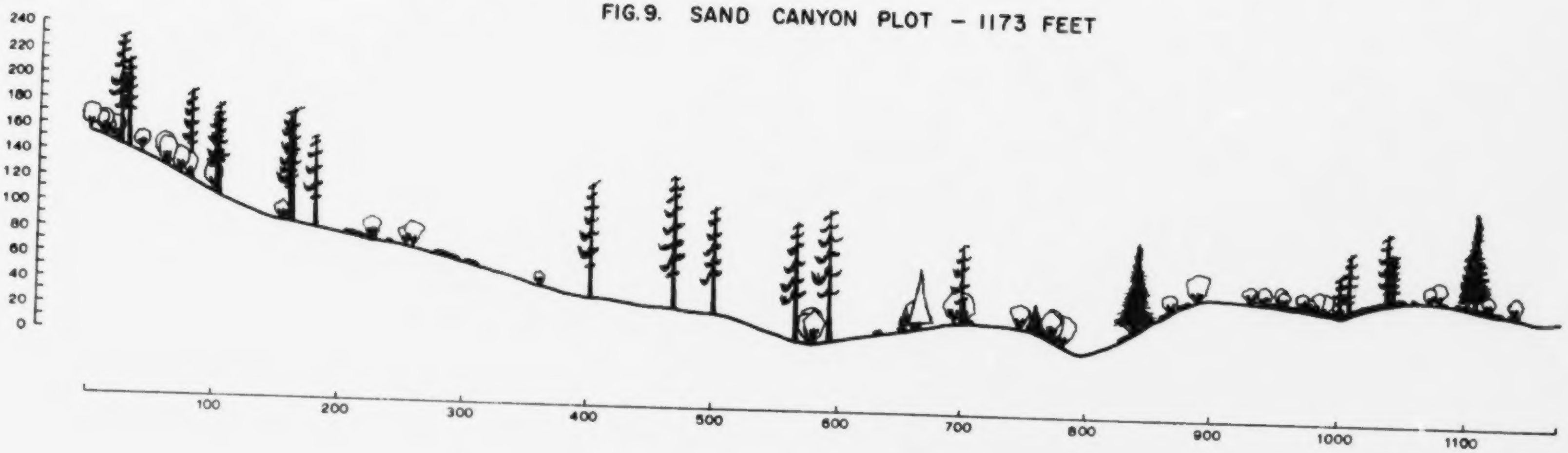
RIBES NEVADENSE
ABIES CONCOLOR
JUNIPERUS OCCIDENTALIS
CHRYSOTHAMNUS NAUSEOSUS
PTERIDIUM AQUILINUM
CEANOTHUS LEUCODERMIS
ARCTOSTAPHYLOS PARRYANA

FIG. 9. SAND CANYON PLOT – 1173 FEET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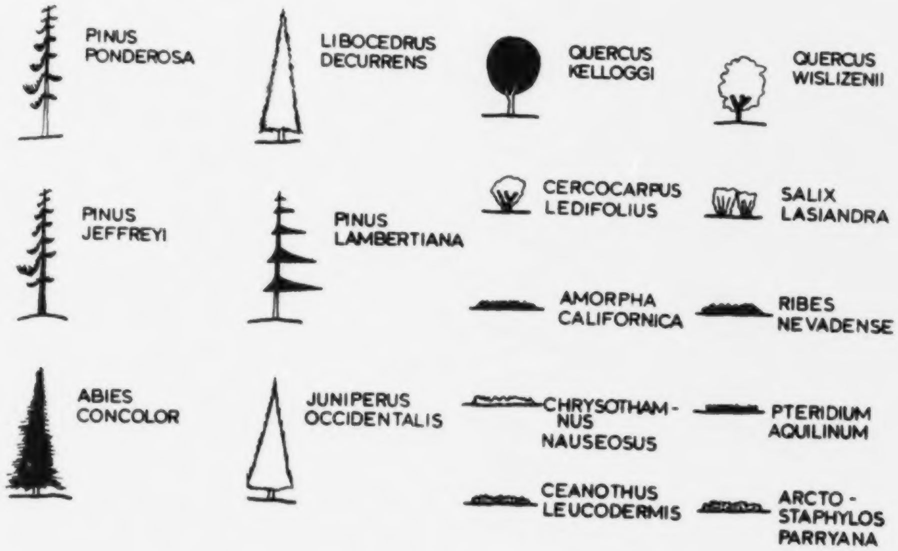
KEY TO TREES AND SHRUBS ON PROFILE MAPS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SALIX LASIANDRA
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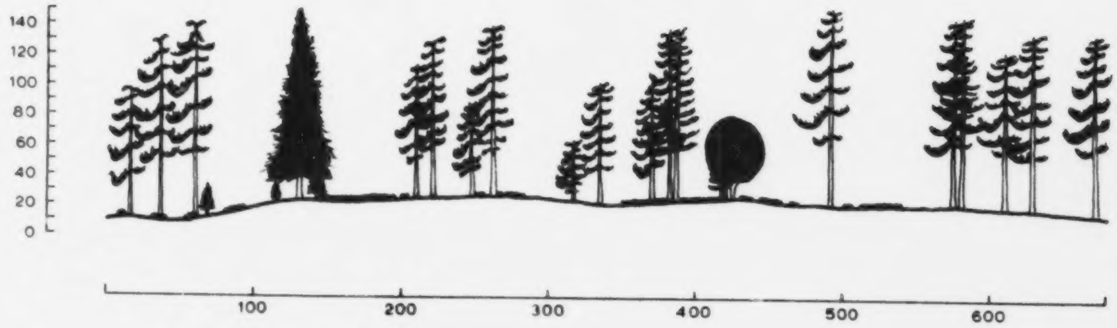
RIBES NEVADENSE
ABIES CONCOLOR
JUNIPERUS OCCIDENTALIS
CHRYSOTHAM-NUS NAUSEOSUS
PTERIDIUM AQUILINUM
CEANOTHUS LEUCODERMIS
ARCTO-STAPHYLOS PARRYANA

FIG. 10. CAMP ANGELES PLOT – 680 FEET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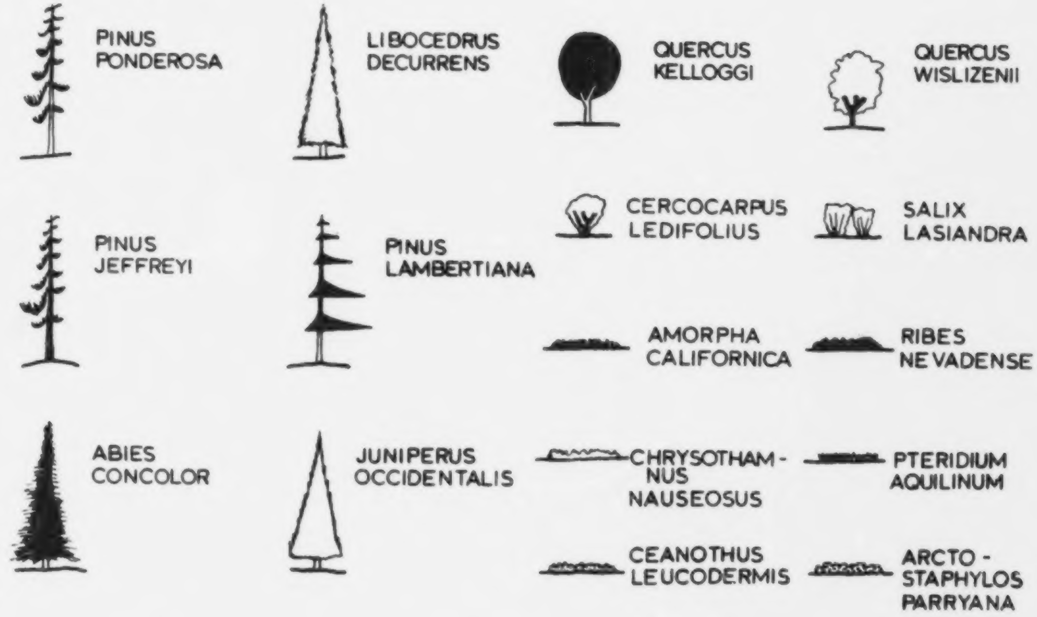
KEY TO TREES AND SHRUBS ON PROFILE MAPS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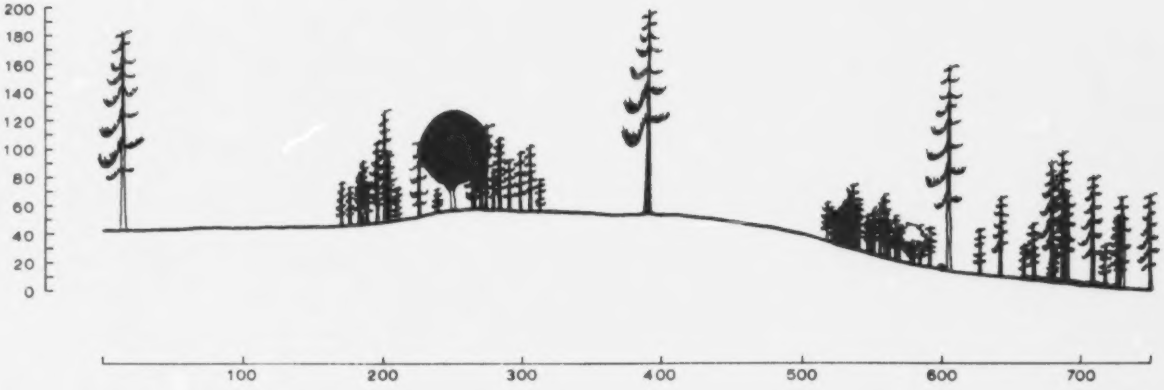
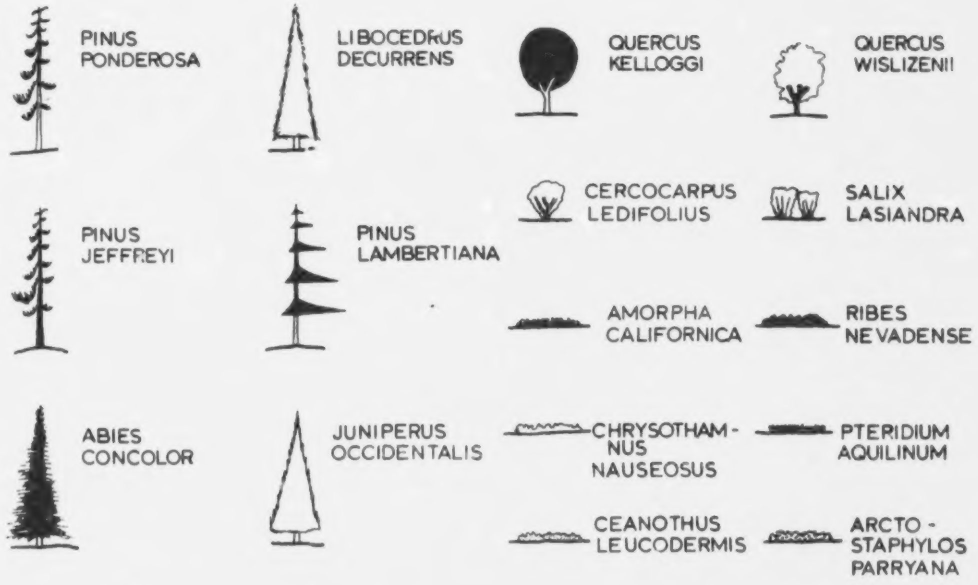
PINUS JEFFREYI
PINUS LAMBERTIANA
AMORPHA CALIFORNICA
RIBES NEVADENSE
ABIES CONCOLOR
JUNIPERUS OCCIDENTALIS
CHRYSOTHAMNUS NAUSEOSUS
PTERIDIUM AQUILINUM
CEANOTHUS LEUCODERMIS
ARCTOSTAPHYLOS PARRYANA

FIG. II. BARTON FLATS PLOT - 750 FEET



KEY TO TREES AND SHRUBS ON PROFILE MAPS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CERCOCARPUS LEDIFOLIUS
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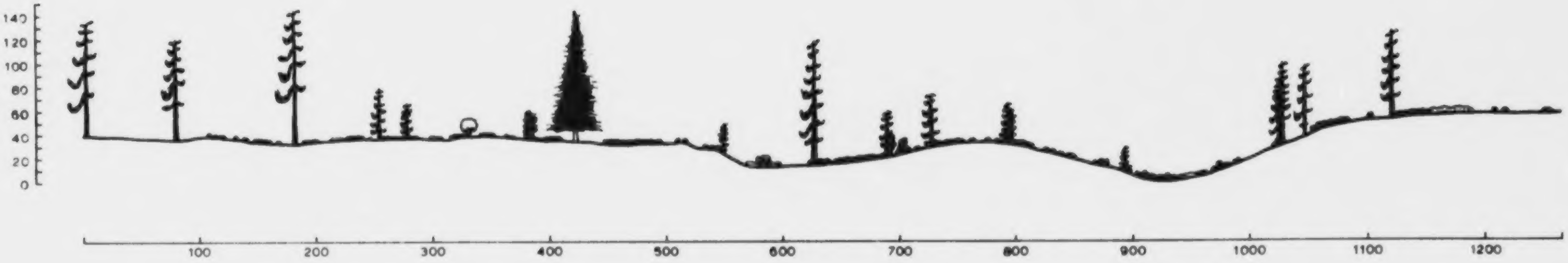
PINUS JEFFREYI
PINUS LAMBERTIANA
AMORPHA CALIFORNICA
RIBES NEVADENSE
ABIES CONCOLOR
JUNIPERUS OCCIDENTALIS
CHRYSOTHAMNUS NAUSEOSUS
PTERIDIUM AQUILINUM
CEANOTHUS LEUCODERMIS
ARCTOSTAPHYLOS PARRYANA

FIG. 12. HEART BAR PLOT — 1265 FEET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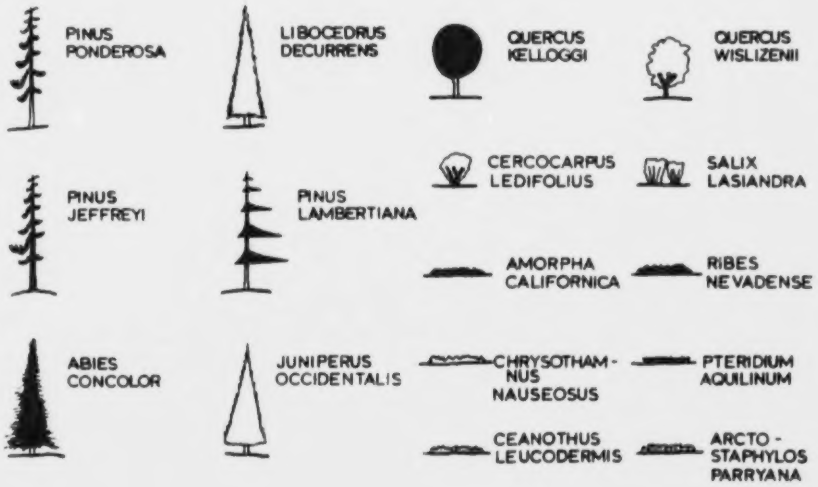
KEY TO TREES AND SHRUBS ON PROFILE MAPS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PINUS LAMBERTIANA
AMORPHA CALIFORNICA
RIBES NEVADENSE
ABIES CONCOLOR
JUNIPERUS OCCIDENTALIS
CHRYSOTHAMNUS NAUSEOSUS
PTERIDIUM AQUILINUM
CEANOTHUS LEUCODERMIS
ARCTOSTAPHYLOS PARRYANA

FIG.13 AGE DISTRIBUTION: DOGWOOD

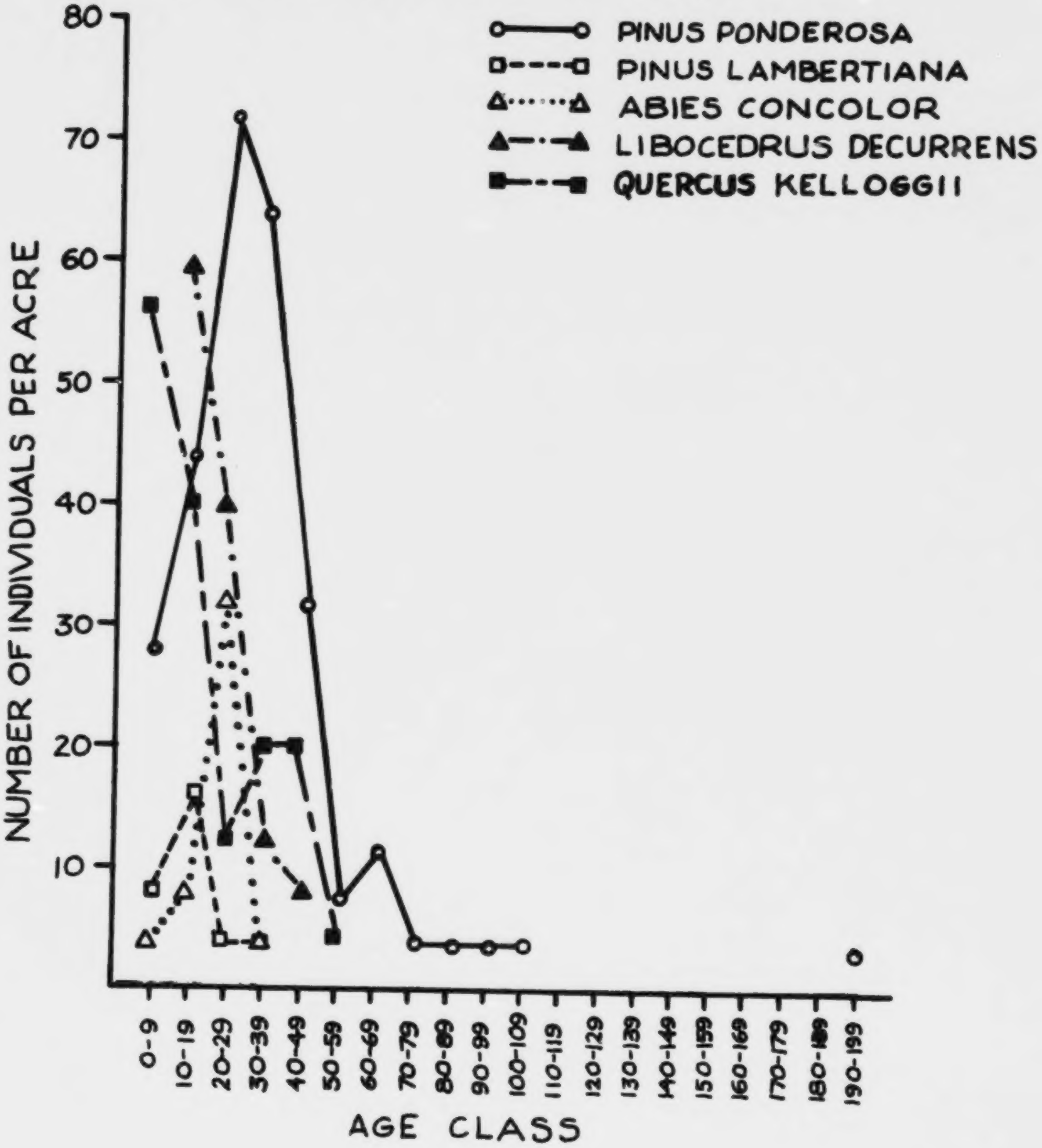


FIG.14. AGE DISTRIBUTION : SNOW VALLEY

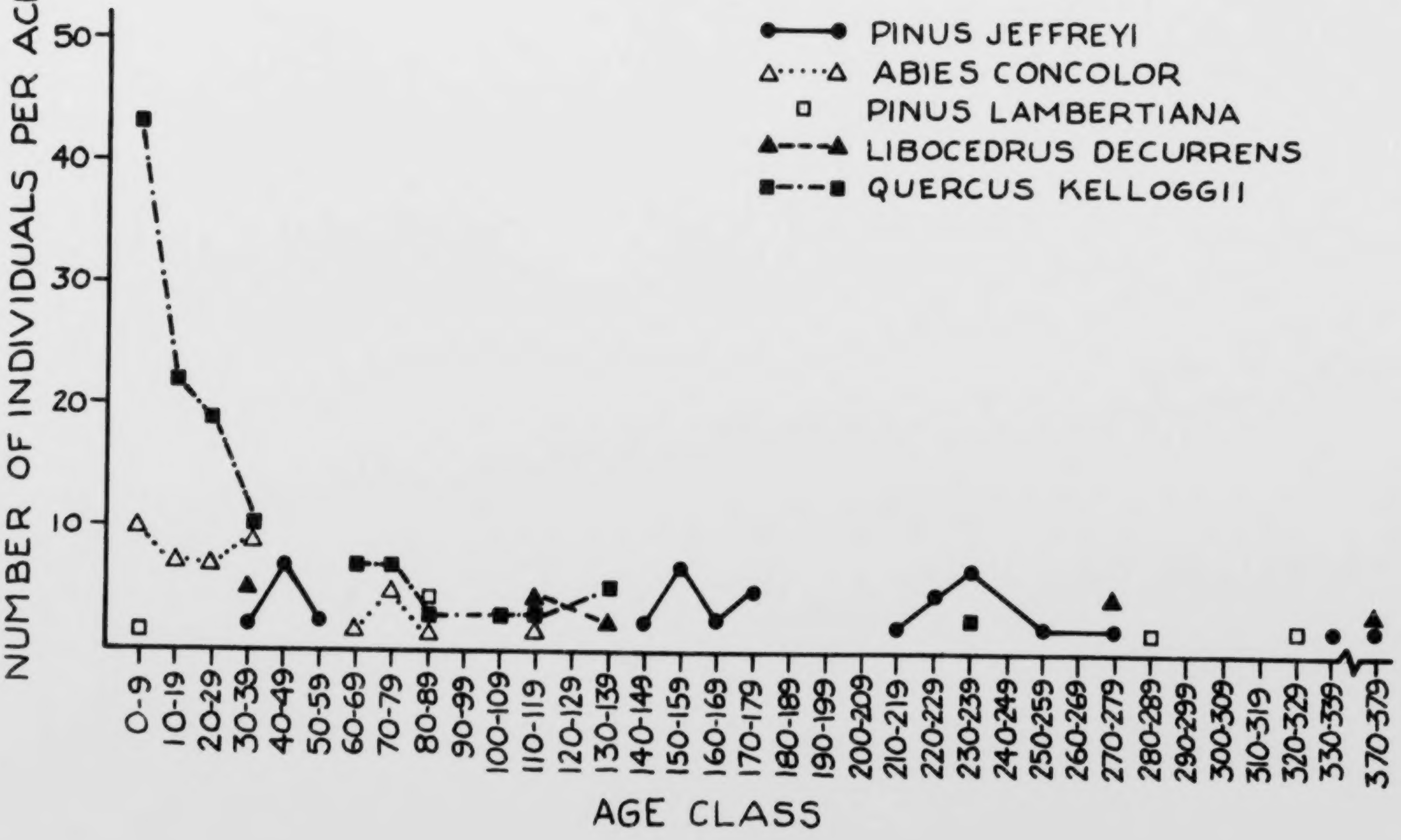


FIG.15. AGE DISTRIBUTION: SAND CANYON

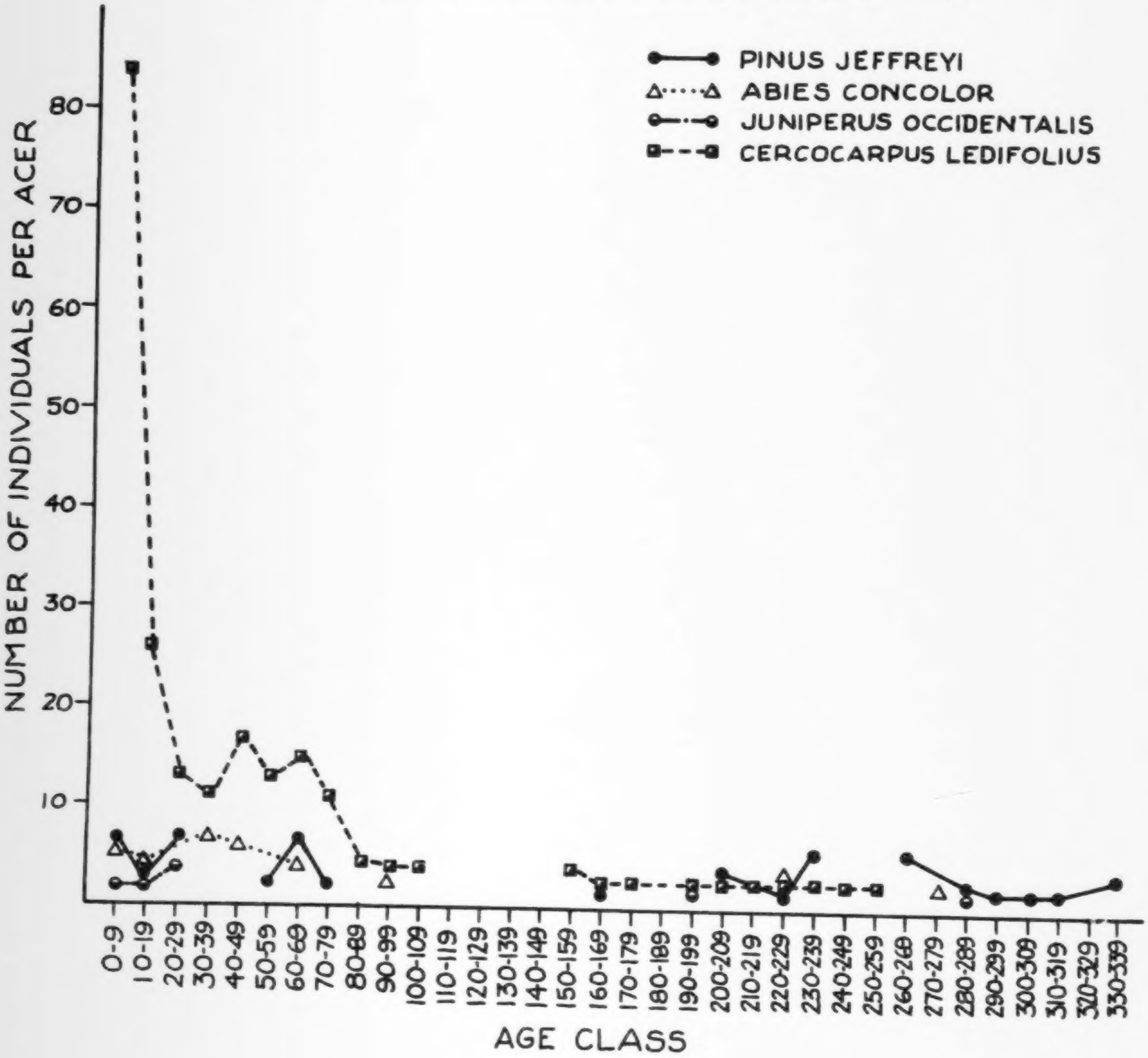


FIG.16 AGE DISTRIBUTION: CAMP ANGELES

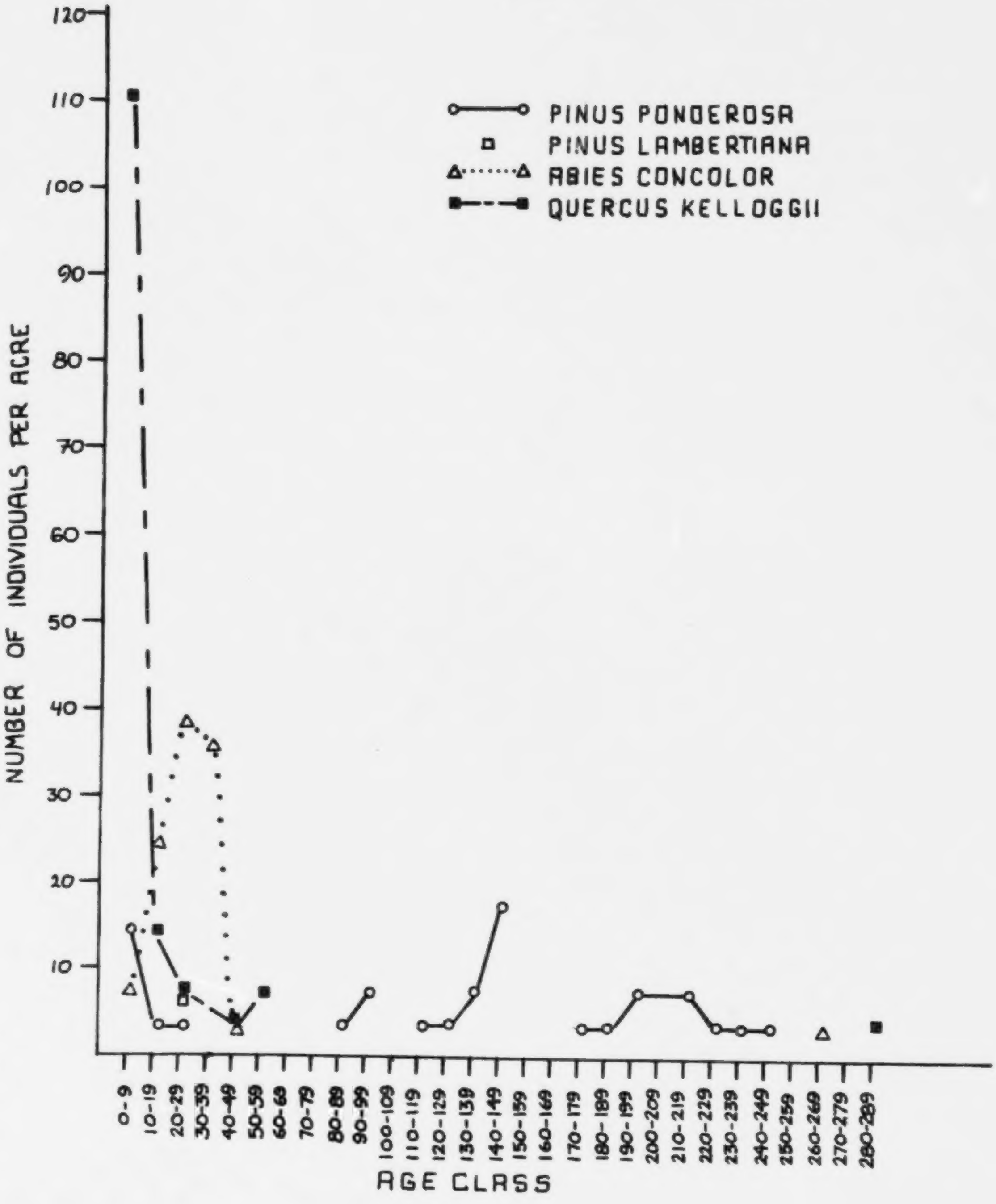


FIG. 17 AGE DISTRIBUTION: BARTON FLATS

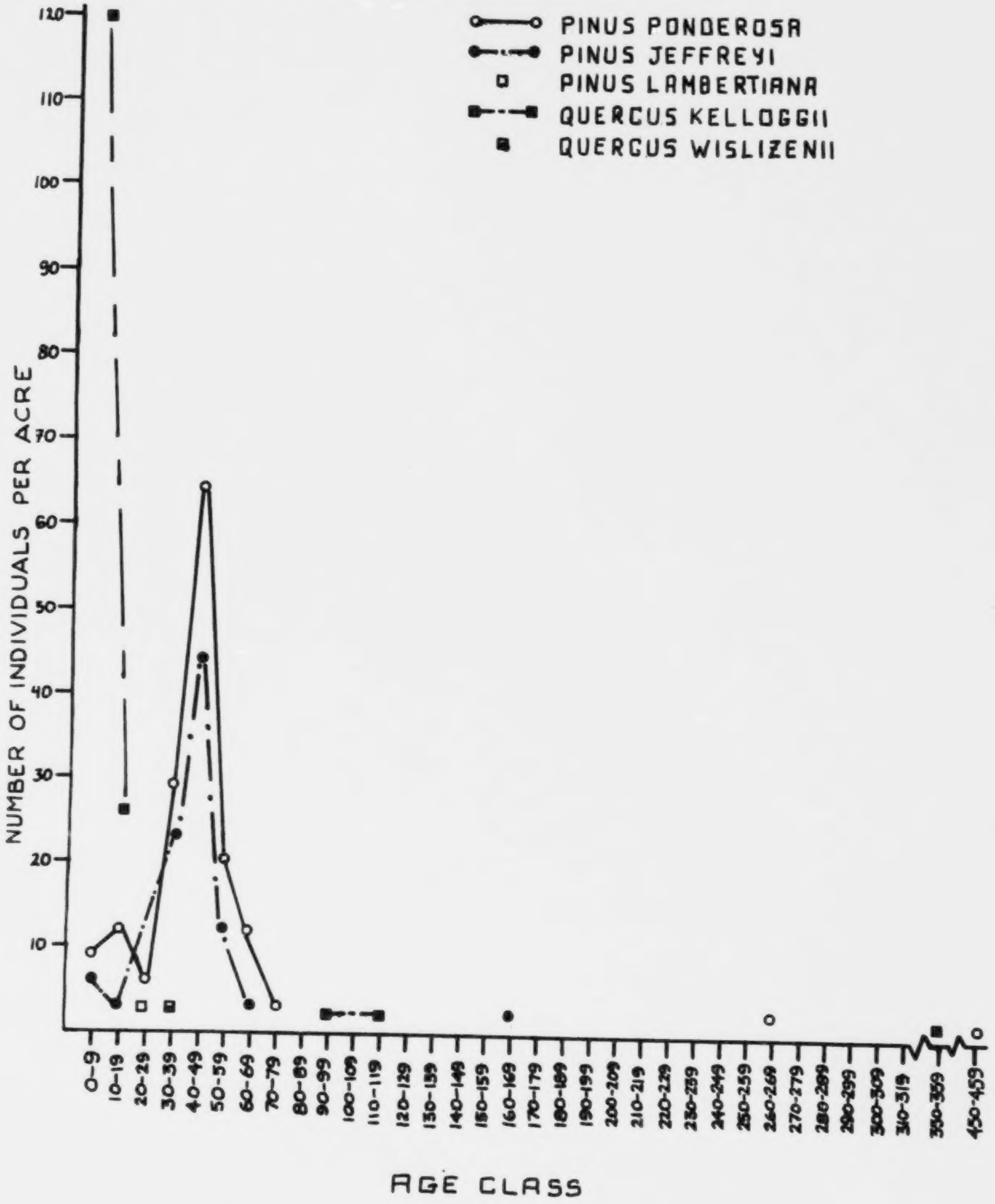
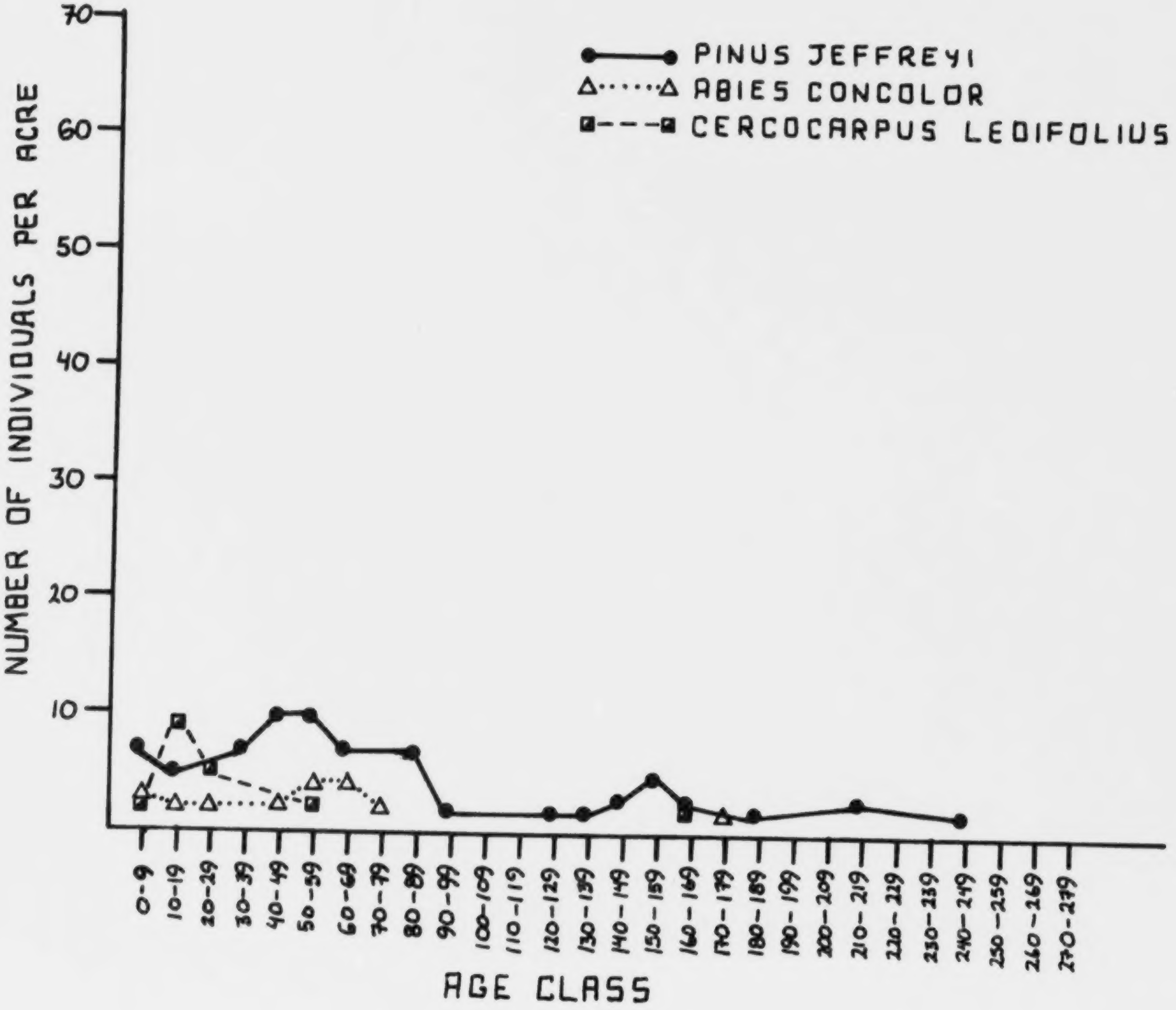


FIG.18 AGE DISTRIBUTION: HEART BAR



Section III

Oxidant Damage to Conifers on Selected Study Sites, 1972

Paul R. Miller

Acknowledgments

The following assisted in data gathering: Dr. Leonard Felix, Dr. Joe McBride, Dr. Fields Cobb, Kenneth Swain, and Ross Thibaud.

Introduction

Two of the six vegetation plots (Fig. 1) were established in 1968 in conjunction with an aerial photography study. The remaining four plots were established in 1972. The original intent was to label 50 ponderosa and/or Jeffrey pines larger than 12 inches diameter at breast height (d.b.h.) per plot and observe them to determine the yearly trends in oxidant damage. The length of 100-foot-wide plots ranged from 550 to 1,200 feet depending on stand density. This activity was a joint project of the U. S. Forest Service, Region 5, Pest Control, and Pacific Southwest Forest and Range Experiment Station.

Objectives of the Task C section of this protocol study were immediately coordinated with the on-going Forest Service work and much additional vegetation, vertebrate, arthropod, and soils data were acquired at the six selected locations. Air quality data (total oxidant) was obtained for nearly 4 months at sites as close as possible to the vegetation plots.

This section of the report compares the present level of damage to all conifers and black oak (when present) with the air quality data gathered nearby.

Mortality and changes in damage scores at the Dogwood and Barton Flats plots from 1968 to 1972 are compared. The incidence of infectious tree diseases is reported in each plot on a tree by tree basis; the incidence of disease and insect fauna both in the plots and the surrounding area are reported in other sections of the report.

Methods

A scoring system for ponderosa and Jeffrey pines which has been tested during the last four years was used to determine the amount of oxidant damage. Key characteristics are assigned a number and a sum of these numbers represents the score for each tree. Binoculars were used routinely to determine needle condition in the upper tree crown; all trees larger than 4.00 inches d.b.h. in each plot were evaluated:

Characteristic:	Score
Needle retention (number of years retained)	
Upper crown	0 ranging up to 6
Lower crown	0 ranging up to 6
Needle condition (one score value given to each annual whorl)	
Upper crown	
Green	4
Chlorotic mottle	2
Uniform yellow or necrosis	0
Lower crown	
Green	4
Chlorotic mottle	2
Uniform yellow or necrosis	0
Needle length (upper and lower crown)	
Average expected length	1
Less than expected length	0

Characteristic: (cont'd)	Score
Branch mortality (lower crown)	
Normal mortality	1
Pronounced mortality	0

Experience has shown that the following descriptions of score ranges for ponderosa and Jeffrey pines are meaningful:

0	-	dead
1-8	-	very severe damage
9-14	-	severe damage
15-21	-	moderate damage
22-28	-	slight damage
29-35	-	very slight damage
36+	-	no visible symptoms

The evaluation of sugar pine was done by the same method used for ponderosa and Jeffrey pine, but because this is the first time that sugar pine has been observed in this way, the descriptions versus score ranges are considered provisional at this time.

Incense cedar and white fir were evaluated for oxidant damage using the same characteristics as those for pine. The resultant score values necessitated the provisional application of different ranges, e.g. white fir: 1-29, 30-59, 60-89, 90+; incense cedar: 1-14, 15-29, 30-44, 45-60. It was not possible to use the needle length characteristic with incense cedar.

Black oak was evaluated by giving separate values for leaf condition in the upper and lower crown (in September and early October): green = 4, slight yellow mottle = 3, moderate yellow mottle = 2, severe mottle with necrosis = 1, complete necrosis = 0. The 0 or 1 scores were given for leaf size (upper and lower) and mortality of small twigs or branches. The provisional score ranges for black oak were: 0-4, 5-9, 10-14, 15+.

The incidence of common tree diseases was tallied at the same time that the trees were inspected for oxidant damage.

Results

Damage versus apparent dosage -- The most easily interpreted description of oxidant damage to ponderosa and/or Jeffrey pines in all six plots relative to dosage is indicated in Figure 1. The most severe damage is at Rim Forest (Dogwood plot; p 14 = ponderosa, average score 14.0). A simple ranking of dosage versus damage follows:

	Dosage (hrs > 0.08 ppm)	Percent dosage	Average damage score
Dogwood	12.6	100	*p 14
Snow Valley	7.9	63	**J 22
Camp Angeles	7.4	59	p 15
Barton Flats	7.3	58	p 19, J 17
Sand Canyon	6.5	51	J 35
Heart Bar	5.7	45	J 34

*p = ponderosa pine
**J = Jeffrey pine

The only serious discrepancy in order of damage and dosage was at Snow Valley. Because the monitoring station was 2-1/2 miles NW at Green Valley Lake, it is possible that Snow Valley received less oxidant exposure than Green Valley Lake. The greatest distance between vegetation plot and monitoring station was at Sand Canyon where the corresponding monitoring station was at Fawnskin on the north shore of Big Bear Lake about five miles NW of Sand Canyon and closer to the pollution source.

It must be emphasized that for the purposes of this report the durations of adverse oxidant observed during this June-October 1972 sample period are being considered as an indication of the relative exposures over the previous 20-25 years. Other important variables including precipitation and soils cannot be included until more data are gathered. These and other environmental factors undoubtedly interact with oxidant to increase or decrease damage.

Relative oxidant damage to six tree species -- A very sensitive indication of oxidant damage to ponderosa and Jeffrey pines was obtained along the transects of decreasing oxidant exposure. The evaluation of the characteristics of oxidant damage to sugar pine was fairly sensitive but observations of incense cedar, white fir, and black oak require much more refinement. Other species prominent on some plots such as mountain mahogany and willow were not evaluated for oxidant damage at all because at the time of examination in September and October, it is difficult to separate symptoms of oxidant air pollution from the normal leaf pigment changes expected in the fall.

The relative numbers of six species in each plot, their average damage score and range of damage scores is presented in Table 1. There is a discontinuity involving ponderosa and Jeffrey pines along both transects. Ponderosa is present along the western lower elevation portions of each transect while Jeffrey pine alone is located in the eastern higher elevation areas. Both species are intermixed at the Barton Flats plot allowing a comparison of oxidant damage under similar conditions. As indicated earlier (Fig. 1), the average damage scores are not really different (ponderosa 19, Jeffrey 17). In Tables 2 and 3, the distribution of ponderosa and Jeffrey pines into damage classes at Barton Flats is not very different. In contrast, the damage class distributions of ponderosa pines at Dogwood and Barton Flats (Table 2) are quite dissimilar as is the comparison of Jeffrey pines at Barton Flats and Heart Bar (Table 3) -- an effect of different oxidant dosages. These data suggest that it will be possible to consider the two species as closely comparable bioindicators of air pollution damage over the broad range that they occupy.

The small numbers of sugar pines in Table 4 makes it difficult to identify any reliable trend in tree condition from plot to plot. The same is true of the information on incense cedar (Table 5), white fir (Table 6), and black oak (Table 7).

A significant number of individual white firs with moderate to severe oxidant damage were encountered at Dogwood and Camp Angeles. Although white fir is less sensitive than ponderosa or Jeffrey pines in general it will be one of the most useful bioindicators because it was the only conifer found at all the plots except Barton Flats (Table 1) and even then there were many just outside the plot.

The improvement of the scoring system for species other than ponderosa and Jeffrey pines is a high priority task. Improvements will include several observations during the summer and fall to follow the progression of symptom development and to identify more reliable characteristics for inclusion in the scoring system.

Rates of mortality and tree deterioration -- Comparisons are made for change in damage class and mortality of individual ponderosa pines at Dogwood (Table 8) and Barton Flats (Table 10) from 1968 to 1972. In both Tables, it is possible to observe the fate of each tree. There are many shifts from higher to lower score classes and a small number of individuals that remained in the two highest classes. On the darker side, the average score at Dogwood decreased by 3.86 and at Barton Flats 2.98, both significant at 0.01 probability. The mortality for the 4-year period was 10 percent and 8 percent, respectively. These two data points (in time) are not sufficient to describe the shape of the mortality curve at the present levels of oxidant dosage.

Incidence of infectious tree diseases -- The frequency of infection of plot trees by several common above-ground pathogens was determined (Table 10). The most serious problem was frequent damage by the Elytroderma needle cast at Sand Canyon and especially at Heart Bar. This fungus, *Elytroderma deformans* (Weir) Darker, is systemic in the twigs from which it invades new needles. Damage intensity varies from year to year and is usually confined to local areas.

Dwarf mistletoe was occasionally present on plot trees. It is known to occur in much higher intensity in areas between and adjacent to the plots where it causes serious damage.

True mistletoe on white fir was a significant problem at Sand Canyon, less important at Heart Bar.

A Dieback of the smaller branch tips of white fir was observed with significant frequency but the cause is unknown.

In general, there was less incidence of above-ground diseases in the plots receiving the highest oxidant dosages. It is not possible to suggest a cause-effect relationship at this time.

Root and heart rots were not encountered on labeled trees in the plots but were present in the immediate vicinity of some plots; the incidences of these diseases are presented in the following section (Cobb-Preliminary Survey).

Summary

The severity of oxidant damage to ponderosa and/or Jeffrey Pines decreased along two overlapping transects for a combined distance of 28 miles. The duration of total oxidant concentrations exceeding 0.08 ppm daily ranged from 12.6 hours at the west end to 5.7 hours at the east during a 4-month sampling period in 1972. This range of oxidant durations was considered a useful estimate of the long-term effects since the early 1950's along the two transects representing increasing distance from the pollution sources -- coastal and inland urban areas. The method for estimating damage to ponderosa and Jeffrey pines was quite

satisfactory. But much additional work is needed to determine the best characteristics for quantitating damage to other conifer and hardwood species, including calibration of a scoring system for each sepcies. It should be feasible to use ponderosa and Jeffrey pines together as interchangeable bioindicators since one does not exist as a continuum from the west to the east end of the mountain area. These species appear to be very similar in their sensitivity to oxidant injury. White fir was present at all plots and will also be a sensitive bioindicator.

The mortality of ponderosa pines in the Dogwood and Barton Flats plots from 1968 to 1972 was 10 and 8 percent, respectively. Damage to the remaining trees increased very significantly. A simple-minded linear projection of this mortality rate would find only 2 or 3 of the original number of trees remaining at Dogwood by 2020. The dynamics of damage and mortality due to oxidant and other interacting agents is a question of extreme importance in the proposed ecosystem study.

There was no serious incidence of tree diseases in the plots themselves except for heavy infections of *Elytroderma* needle cast on Jeffrey pines at the eastern plots, particularly Heart Bar.

Recommendations for Future Work

1. Stretch the study area as far from west to east as the extent of the conifer forest will allow. This would include installation of similar observation plots west of Dogwood and east of Heart Bar.

2. Replicate the sample plots by choosing new locations of similar vegetation cover within the present study area.

3. Investigate locations in northern Baja California where stands of Jeffrey pine may provide two or three control plots where oxidant air pollution does not exist.

4. Improve procedures for evaluating the severity of oxidant damage on species other than ponderosa and Jeffrey pines, including other conifers, hardwoods, shrubs and herbs.

Table 1. Summary of species composition at each plot location including average damage score and range of damage scores for each species.

		Ponderosa pine	Jeffrey pine	Sugar pine	Incense cedar	White fir	Black oak
Dogwood (100)	N	82	0	3	28	8	15
	Ave.	14.6	0	39.0	27.0	46.4	4.9
	Range	1-31	0	34-43	9-57	22-68	1-8
Snow Valley (63)[1]	N	0	74	13	29	31	39
	Ave.	0	22.3	35.0	27.3	84.5	9.6
	Range	0	10-43	24-65	15-58	42-118	5-31
Camp Angeles (59)	N	68	0	5	0	37	19
	Ave.	15.5	0	21.4	0	76.4	5.4
	Range	4-51	0	12-37	0	32-121	3-8
Barton Flats (58)	N	129	83	0	0	0	14
	Ave.	18.9	17.3	0	0	0	7.1
	Range	5-45	1-41	0	0	0	3-10
Sand Canyon (51)	N	0	62	0	0	17	0
	Ave.	0	35.0	0	0	76.2	0
	Range	0	20-49	0	0	26-102	0
Heart Bar (45)	N	0	104	2	0	18	0
	Ave.	0	34.3	27.0	0	73.2	0
	Range	0	12-54	69-70	0	41-92	0

---

[1] Percent of the hours daily (12.6 hr) at Rim Forest when oxidant concentrations exceeded 0.08 ppm from June through September 1972.

Table 2. The distribution of ponderosa pines in six damage classes at three locations.

Plot name		Damage Classes					
		1-8	9-14	15-21	22-28	29-35	36+
Dogwood (100)	N	5	42	24	7	2	0
	%	6.3	52.5	30	8.7	2.5	0
Camp Angeles (59) [1]	N	5	28	26	7	1	1
	%	7.4	41.2	38.2	10.3	1.5	1.5
Barton Flats (58)	N	14	34	41	22	16	9
	%	10.3	25.0	30.1	16.2	11.8	6.6

---

[1] Percent of the hours daily (12.6 hr) at Rim Forest when oxidant concentration exceeded 0.08 ppm from June through September 1972.

Table 3. The distribution of Jeffrey pines in six damage classes at four locations.

Plot name		Damage Classes 1-8	9-14	15-21	22-28	29-35	36+
Snow Valley (63) [1]	N %	0 0	4 5.5	35 48.6	23 32.0	7 10.0	3 4.2
Barton Flats (58)	N %	15 18.0	16 19.0	35 41.7	10 12.0	6 7.1	2 2.4
Sand Canyon (51)	N %	0 0	0 0	2 3.4	9 15.2	25 42.4	23 39.0
Heart Bar (45)	N %	0 0	2 2.0	9 8.7	18 17.5	33 32.0	41 39.8

[1] Percent of the hours daily (12.6 hr) at Rim Forest when oxidant concentrations exceeded 0.08 ppm from June through September 1972.

Table 4. The distribution of sugar pines into six damage classes at four locations.

Plot name		Damage Classes 1-8	9-14	15-21	22-28	29-35	36+
Dogwood (100)	N	0	0	0	0	1	2
	%	0	0	0	0	33.3	66.6
Snow Valley (63) [1/]	N	0	0	1	5	3	5
	%	0	0	7.2	35.7	21.4	34.7
Camp Angeles (59)	N	0	2	1	1	0	1
	%	0	40.0	20.0	20.0	0	20.0
Heart Bar (45)	N	0	0	0	1	0	1
	%	0	0	0	50.0	0	50.0

[1/] Percent of the hours daily (12.6 hr) at Rim Forest when oxidant concentration exceeded 0.08 ppm from June through September 1972.

Table 5. The distribution of incense cedar into four damage classes at two locations.

Plot name		Damage Classes			
		1-14	15-29	30-44	45-60
Dogwood (100)	N	3	15	10	1
	%	10.3	51.7	34.5	3.4
Snow Valley (63) [1]	N	1	18	7	1
	%	3.7	66.6	26.0	3.7

---

[1] Percent of the hours daily (12.6 hr) at Rim Forest when oxidant concentration exceeded 0.08 ppm from June through September 1972.

Table 6. The distribution of white firs into four damage classes at five locations.

Plot name		Damage Classes			
		1-29	30-59	60-89	90+
Dogwood (100)	N	2	4	2	0
	%	25.0	50.0	25.0	0
Snow Valley (63) [1]	N	0	4	19	9
	%	0	12.5	59.4	28.1
Camp Angeles (59)	N	0	10	14	13
	%	0	27.0	38.0	35.0
Sand Canyon (51)	N	0	2	13	2
	%	0	11.8	76.4	11.8
Heart Bar (45)	N	0	4	12	2
	%		20.0	60.0	10

---

[1] Percent of the hours daily (12.6 hr) at Rim Forest when oxidant concentration exceeded 0.08 ppm from June through September 1972.

Table 7. The distribution of black oaks into four damage classes at four locations.

Plot name		Damage Classes 0-4	5-9	10-14	15+
Dogwood (100)	N	7	8	0	0
	%	47.0	53.0	0	0
Snow Valley (63) [1/]	N	1	23	13	2
	%	2.6	59.0	33.3	5.1
Camp Angeles (59)	N	5	14	0	0
	%	26.0	74.0	0	0
Barton Flats (58)	N	1	12	2	0
	%	6.7	80.0	13.3	0

[1/] Percent of the hours daily (12.6 hr) at Rim Forest when oxidant concentration exceeded 0.08 ppm from June through September 1972.

Table 8. Mortality rate and changes in camage scores of individual ponderosa pines at the Dogwood plot, 1968-1972.

1968

Average score		5.6	11.1	17.3	26.3	35.0	--
		100					
		96,97					
		92,94	99				
		84,87	90,91				
		77,83	86,88				
		69,72	80,85				
		64,65	76,78	93,98	74,82		
		59,60	61,71	75,81	68,70		
	--	53,57	52,56	58,73	55,63	89	--
Score classes	0(dead)	1-8	9-14	15-21	22-28	29-35	36+

1972

Average score		5.1	10.0	15.8	25.5	--	--
		99,100					
		92,94					
		87,90	98				
		80,86	91,96				
		76,77	85,88				
		61,64	82,84	97			
	69,83	59,60	75,78	81,93			
	52,65	57,58	56,72	70,71	74,68	55,89	--
Score classes	0(dead)	1-8	9-14	15-21	22-28	29-35	36+

Mortality 1968-1972 = 10%

Average Score Difference 1968-1972 = 3.86
(significant at 0.01 probability)

Table 9. Mortality rate and changes in damage scores of individual ponderosa pines at the Barton Flats plot, 1968-1972.

1968

Average score		6.8	12.3	19.2	26.0	31.3	44.4
	--	49 43,47 14,35	17,42 12,15 7,9 4,5	41 38,40 36,37 33,34 31,32 24,25 16,22 6,13 1,3	30,48 11,27 2,10	50 45,46 29,44 26,28 8,18	39 21,23 19,20
Score classes	0(dead)	1-8	9-14	15-21	22-28	29-35	36+

1972

Average score		4.0	11.8	19.7	26.8	27.4	40.3
	38,49 15,31	17,35 12,14 7,9	47 25,43 4,24	42 36,41 32,33 22,27 6,11	40,45 28,37 18,26 13,16 5,10 1,2	48,50 44,46 30,39 23,29 3,8	21 19,20
Score classes	0(dead)	1-8	9-14	15-21	22-28	29-35	36+

Mortality 1968-1972 = 8%

Average Score Difference 1968-1972 = 2.98
(significant at 0.01 probability)

Table 10. Incidence of common infectious aboveground diseases in each of the six study plots.

	Dogwood	Snow Valley	Camp Angeles	Barton Flats	Sand Canyon	Heart Bar
	Disease Incidence/Total Trees Each Species					
Dwarf mistletoe						
Jeffrey pine	--	0/74	--	6/83	0/62	0/104
Ponderosa pine	0/82	--	6/68	0/129	--	--
Sugar pine	0/3	0/13	2/5	--	--	0/2
True mistletoe						
White fir	0/8	1/31	0/37	--	6/17	3/18
Incense cedar	0/28	2/29	--	--	--	--
Black oak	0/15	0/39	0/19	1/14	--	--
Elytroderma deformans						
Jeffrey pine	--	1/74	--	0/83	18/62	47/104
Ponderosa pine	0/82	--	0/68	1/129	--	--
Branch tip dieback (cause unknown)						
White fir	0/8	11/31	0/37	--	4/17	10/18

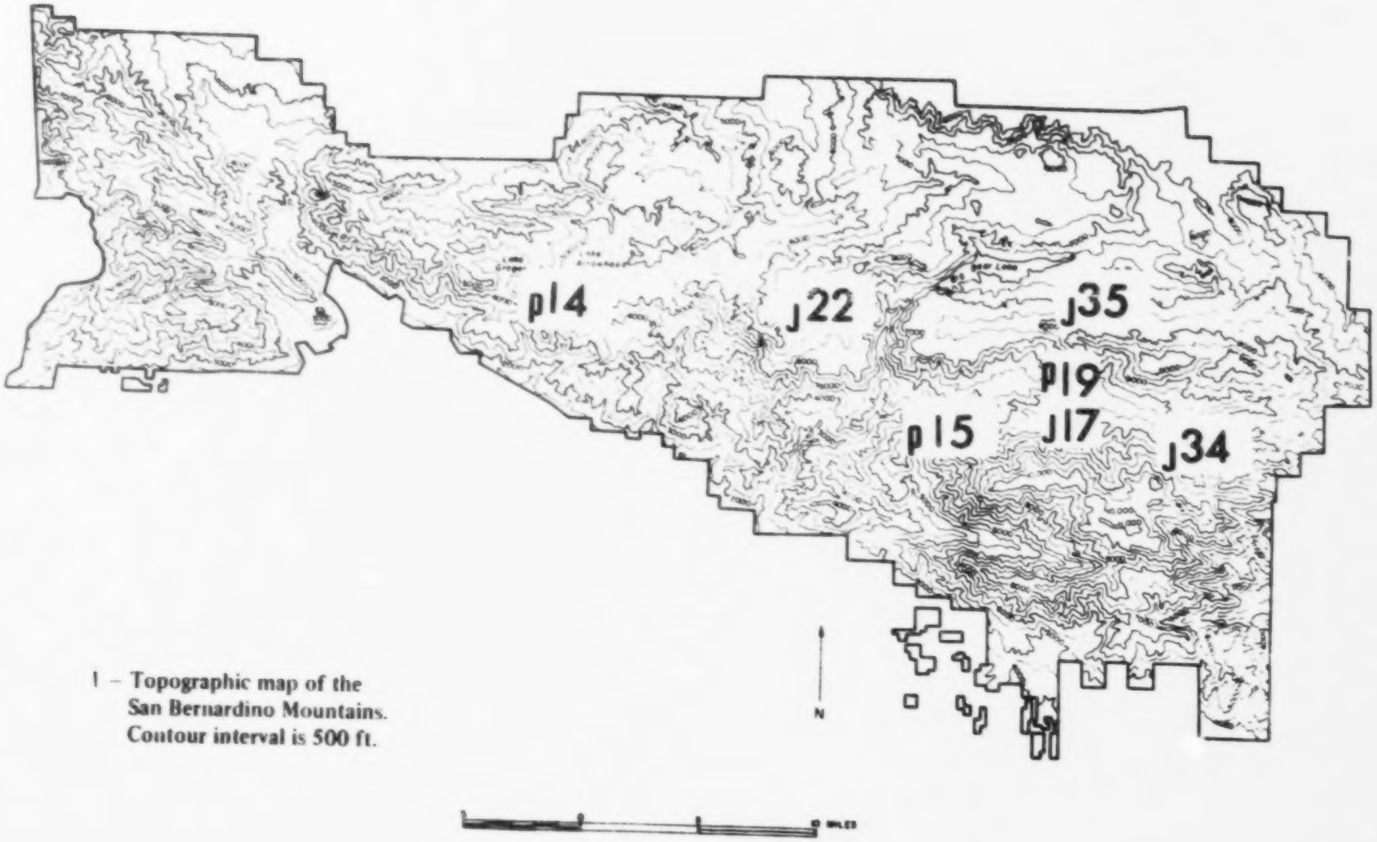

p14
J22
J35
P19
J17
p15
J34
N
1 – Topographic map of the
San Bernardino Mountains.
Contour interval is 500 ft.

Figure 1. Injury to ponderosa or Jeffrey pines decreases (larger score) with distance from pollutant sources

Section IV

A Preliminary Survey of Plant Disease Problems in the San Bernardino Mountains

Field W. Cobb

A survey of disease problems was made in and around plots (see General Introduction) established along air pollution gradients in the San Bernardino Mountains. The survey was made during the last week in August, 1972. Thus, the observations made must be evaluated relative to the seasonal occurrence of some pathogens and/or symptoms. Other problems of significance might be detected earlier in the season. The survey was conducted concurrently with one on insect pests but did not involve a plant taxonomist familiar with the grasses, herbaceous plants or some of the shrubs. As a consequence, few observations were made on these latter plant species.

Since the purpose of the survey was to obtain information that would assist in planning a project on the influence of pollution on the mixed-conifer ecosystem, striking absences of plant pathogens and parasites as well as the occurrence of these organisms were noted.

Dogwood Plot

Vegetation is mixed-conifer, predominantly ponderosa pine but with black oak, white fir, incense cedar and sugar pine in that order of abundance. Mortality in ponderosa pine was 10 percent from 1968 to 1972; these trees were showing substantial pollution injury and many had been attacked by bark beetles. Observations and isolations yielded no evidence of root decay organisms although deterioration of the small rootlet systems by faculative parasites is highly probable. No dwarf mistletoe and needle casts were observed in this stand. A few of the white firs and incense cedars were dead or showing symptoms of reduced vigor. Examination of the root collar zones on several of these trees indicated that root decay, e.g., Fomes annosus on white fir, might be involved but isolations failed to confirm this. The black oak was generally in a state of decline with moderately severe branch cankering. Isolations from oak cankers consistently yielded a dark pigmented fungus, as yet unidentified. Fruiting structures of slash or litter decaying fungi and mycorrhizal fungi were conspicuously absent although there had been recent rains. In summary, the abundance of cankering on oak branches, the lack of sporophores of decay organisms or mycorrhizal fungi, and the absence of evidence of the occurrence of Armillaria mellia on weakened trees may be significant relative to the occurrence of air pollution. The apparent absence of dwarf mistletoes and needle casts probably have no relationship with air pollution in the case of this plot, although it cannot be ruled out relative to the needle casts.

Snow Valley

Vegetation is predominantly Jeffrey pine with a few white firs and black oak. Relatively sparse brush is predominantly Ceanothus with some manzanita. Jeffrey pine on the site has light to moderate infection by Elytroderma deformans, a needle cast fungus. Dwarf mistletoe in the pine is moderate to heavy. A few pines and white firs have been killed by bark beetles after infection by Fomes annosus. F. annosus has been confirmed by isolation. Some of the white firs have moderate infection by true mistletoe. Black oak is generally in better condition than at Dogwood with less dieback and cankering. The Ceanothus has moderate cankering. Isolations have yielded a brown pigmented fungus. Armillaria mellea was not observed on any of the conifers, but this may not be surprising here because of the more widely spaced trees.

Heart Bar State Park

Timber vegetation is predominantly Jeffrey pine with some white fir. Understory is manzanita, *Ceanothus*, Mt. Mahogany and, in the wetter drainage, willow and cottonwood. Both Jeffrey pine and white fir appear to be in poor condition, with a significant number of dead trees of both species. Major cause of mortality in both species appears to be *Fomes annosus* root rot followed by bark beetles. *Fomes annosus* has been confirmed by isolation. Brown cubical root and butt rot caused by *Polyporus schweinitzii* was also confirmed in several of the Jeffrey pines. Occurrence of limb rust on several Jeffrey pines is also suspected, and *Elytroderma deformans* infection is light to moderate. Other needle diseases of pine appear to be absent. The white fir has moderate to heavy infection by true mistletoe and several firs have extensive heart rot decay by *Echonodontium tinctorium*. White fir twig dieback apparently caused by an unidentified canker fungus is also extensive, especially in the lower parts of the crowns. Manzanita, *Ceanothus* and Mt. Mahogany have moderate to heavy branch cankering. The cause(s) of manzanita cankers appears to be the same as in other parts of California. The same brown-pigmented fungus was isolated from *Ceanothus* on this plot as from the same plant on other plots.

Camp Angelus

Vegetation tending toward the mixed-conifer, predominantly ponderosa pine with some oaks and white fir. Ponderosa pine appears to be reasonably vigorous. Pine mortality is light to moderate; a few trees may have *F.annosus* but this has not been confirmed. *Armillaria mellea* occurred on one of the pines. Elytroderma infection appeared to be very light, and dwarf mistletoe in pine was heavy in a single infection center. The white fir was generally in good condition but a significant number of trees less than 4 inches dbh were severely damaged by oxidant; no cankering or root diseases were observed. Infection by true mistletoe was light in fir but heavy in black oak. Branch dieback on oak was present but not severe in those trees receiving full sunlight.

Barton Flats

Vegetation is predominantly ponderosa and Jeffrey pine with some black oak. Dwarf mistletoe is occasionally encountered on pines with heavy main stem infection in the younger trees. Mortality of pine was 9 percent from 1968 to 1972. Bark beetles, pollution injury and Fomes annosus are contributing to the mortality; that caused by F. annosus appears to be significant but this has not been confirmed by isolations from dying trees. Several of the black oaks have moderate cankering and dieback as well as moderate true mistletoe infection. No Armillaria was found.

Sand Canyon

Site appears to be dry with Jeffrey pine predominating. There are some white firs, pinon pine, and juniper in the overstory. Understory is predominantly mountain mahogany, manzanita and Ceanothus. There is moderate Elytroderma needle cast infection in the Jeffrey pine, but little or no dwarf mistletoe. The white fir has moderate true mistletoe infection and a few trees have been top-killed. Heart rot (E. tinctorium) is also present in white fir as is a light amount of branch cankering. No serious problems were observed on the pinon pine and juniper. The mountain mahogany has moderate dieback. Cankering on manzanita is light and on *Ceanothus*, it is moderate.

Summary

The major pathogenic or parasitic organisms affecting several of the major plant species in the San Bernardino Mountains appears to be the following:

Pines -- Root pathogens, including *F. annosus*, *P. schweinitzii*, and in some areas *Armillaria mellea*. Little is known about the damping-off fungi, the so-called "soft rots" or other fungi that infect the rootlets only. Dwarf mistletoe. *Elytroderma deformans*. Limb rust.

White fir -- Root pathogens. True and dwarf mistletoe. Canker organisms. *Echonodontium tinctorium* heart rot.

Incense cedar -- Root pathogens.

Mt. Mahogany -- Canker organisms.

Black oak -- Canker organisms. True mistletoe. Root pathogens.

Manzanita -- Canker organisms. Root pathogens.

Ceanothus -- Canker organisms.

Section V

Soil Investigations 1972

R. J. Arkley

Field Examinations of Soil Morphology

Initial exploratory studies of the soils on six selected plots were begun in November 1972. The six plots are located along with pollution gradients; three plots (Crest Park near Lake Arrowhead, Snow Valley west of Big Bear Lake, and Sand Canyon east of Big Bear Lake) form one sequence, and Camp Angeles, Barton Flats, and Heart Bar, all in the vicinity of Mt. San Bernardino, form another. The two sequences differ in soil parent materials. The first contains residual soils formed directly on weathered granitic rocks; the second contains soils formed on colluvial material classified as "fanglomerate and landslide breccia" of the Cushenbury Springs formation of Pleistocene age.

In order to obtain comparable stands of pine forest along the pollution gradients it was found necessary to vary the altitude of the plots. The approximate altitudes are as follows:

Crest Park	5600 ft	Camp Angeles	5760 ft
Snow Valley	6800 ft	Barton Flats	6240 ft
Sand Canyon	7500 ft	Heart Bar	6720 ft

Based upon multiple regression equations using air temperature, altitude, plant cover, and latitude, the mean annual soil temperatures at these sites can be expected to vary from about 51°F at Crest Park to 41°F at Sand Canyon, with consequent differences in soils. However, the effects of these differences can probably be sorted out by study of tree growth rates and tree rings prior to the onset of air pollution.

Soil profiles were examined at four of the six sites; the other two were inaccessible due to unseasonal heavy snows. The soils at Crest Park and at Camp Angeles were found to be of somewhat similar character in spite of the difference in parent materials, although they differed markedly in content of coarse fragments.

The soil at Crest Park is classified tentatively as an unnamed Pachic Ultic Argixeroll, find loamy, mixed mesic soil. This classification translates into a soil with a thick, dark sandy loam surface horixon and an acid, textural B horizon (sandy clay loam texture) of mixed clay mineralogy and moderate soil temperature regime. The soil reaction is moderately acid in the surface (pH 5.8) and slightly more acid in the subsoil (38 to 56+ inches) (pH 5.5) by solorimetric estimate. Dense partially weathered granitic bedrock was encountered at 56 inches.

The soil at Camp Angeles is a Shaver stony fine sandy loan classified tentatively as a Pachic Ultic Haploxeroll, coarse loamy, mixed mesic soil. This classification reflects also a thick, dark surface horizon, with no textural B horizon but rather a subsoil of the same texture as the surface and which is increasingly acid with depth. The pH of the surface is near neutral, grading to pH 5.5 at 37 inches and below. The underlying material is stony granitic colluvial material.

Thus, the main difference in the two soils is in stoniness and in the developed textural B horizon. The two are similar in the thick dark surface soil and increasing acidity with depth.

The soil at Snow Valley is a Corbett loamy coarse sand classified tentatively as a Typic Xeropsamment, mixed frigid soil, which is a soil with only a thick dark surface with no textural profile development, mixed mineralogy, and a cold temperature regime (<47°F, mean annual soil temperature). Reaction is slightly acid in the surface and strongly acid in the lower C horizon. Hard weathered granitic rock was found at the 26 inches depth.

The Barton Flat site is located on a ridge which has a configuration suspiciously like a moraine at the lower boundary of a meadow. However, the geologic maps of the area only show glacial deposits at higher elevations. Because of the stoniness of this soil it was impossible to determine the type of soil without power equipment such as a back hoe, although it was found that the soil was dark and rich in organic matter to a depth of about 12 inches and could be quite similar to the stony Shaver soil at Camp Angeles which was examined in a road cut.

Implications for Research Investigations

As a result of these observations, it is clear that in order to sample and monitor the noisture regimes of these soils it will be necessary to excavate the soil at representative sites with power equipment such as a backhoe in order to install moisture sensors and to obtain quantitative measures of the content of coarse rock fragments in the soils during the excavation procedure. A general procedure might be to excavate a narrow trench parallel to the slope, screen and measure the rock fragments in the pit by increments of depth during the excavation process, collect soil samples, describe the soil morphology in detail, install sensing and measuring devices laterally from the trench into the soil, seal that side with heavy plastic film, and then refill the trench. The plastic film would be used to prevent laterla movement of moisture to or from the disturbed trench-fill.

Section VI

Monitoring Oxidant Air Pollution in the San Bernardino Mountains, June-September 1972

Paul R. Miller and Henry P. Milligan

Introduction

Six stations were located in two overlapping transects each extending from west to east but in entirely different terrain (Figure 2). The three northern stations occupied two ridgetop positions at Rim Forest (5,640 ft.) and Green Valley Lake (6,880 ft.), and a side hill position on the north shore of Big Bear Lake at Fawnskin (6,900 ft.). The southern stations were located on the north-facing slope of the Santa Ana River drainage basin at Camp Angeles (5,800 ft.), Barton Flats Visitor Center (6,320 ft.) and Heart Bar State Park headquarters (6,688 ft.).

The northern transect was 18 miles long, the southern was 13 miles and because they overlapped, the total distance from west to east was 28 miles going from higher to lower exposures to air pollution.

Monitoring stations were located as close as possible to the six vegetation plots where the evaluations of tree damage were made relative to distance from the pollution source.

Instruments and Procedures

Mast ozone meters and Leeds and Northrup Speedomax H strip chart recorders were used at each station. The instruments were locked in a ventilated metal or plywood box just large enough to accommodate both pieces of equipment side-by-side. The Teflon air sampling tube extended 6 to 8 inches from the box. The box had legs which raised it about 3 ft. above the ground.

The box was usually positioned 30 to 75 ft. away from houses or other obstructions which would modify the flow of polluted air from the direction of the urban basin. At five stations power was supplied from a 115 AC, 60 Hz outlets. At one station a small thermoelectric, propane-fueled generator provided DC current which was converted to AC for the instruments. Interference of exhaust gases from the generator with the ozone sensor was virtually eliminated by placing the generator about 75 ft. away in the dominantly upwind direction at Heart Bar State Park.

The monitoring stations were maintained on a Monday, Wednesday, Friday schedule. The round trip mileage was nearly 200 miles. It was necessary to follow a checklist at each station because heat, smog, and driver fatigue sometimes caused the omission of a vital function which could result in the loss of 3 days' data (see the checklist).

Mast ozone meters were returned to the Air Pollution Research Center at Riverside for maintenance and calibration every 4 to 6 weeks. Because the elevation at Riverside and the various stations was different by 4,000 to 6,000 ft., it was necessary to apply a positive correction factor at each station. The correction factor was obtained by dividing the pressure (mb) at Riverside and the calibration point by the pressure (mb) at the sample point.

The hourly oxidant concentration, maximum for the day, and time of the daily maximum were transferred from the strip charts to summary sheets and then card punched. The computer print-out included corrections for the calibration and elevation factors as well as hourly and daily means for each month and the number of hours daily when total oxidant exceeded .08 ppm.

Checklist for Oxidant Monitoring Station Maintenance

Station Number____________________ Station Location____________________

Date____________________ (month-day-year) Date____________________ (Julian - year)

Time: Arrival and Shutdown____________________ 0100 - 2300

Mast Ozone Meter: Serial number____________________. K Factor____________________.

1. Add fresh solution to supply reservoir____________.
2. Pour spent solution from exhaust reservoir leaving enough to cover tygon tube____________.
3. Inspect supply reservoir and remove dirt____________.
4. Inspect both sides of sensor block____________, if necessary, remove air bubbles, dirt____________.
5. Check to insure firm connection of,
   (a) Teflon air sampling tube____________.
   (b) Tygon tube below sensor cell____________.
   (c) Signal wire from sensor cell________.
6. Check for date when meter must be taken down for repair and calibration____________________.
7. Lubricate air pump and solution pump cam. every 2 weeks,
   Needed____________.
   Not Needed____________.
8. If necessary, replace meter in case of malfunction,
   Needed____________.
   Not Needed____________.
9. RESTART Mast meter making certain that switch is on Remote ________________.

Checklist for Oxidant Monitoring Station Maintenance (Cont'd)

Strip Chart Recorder

1. Label chart paper: Station__________
   Time__________
   K Factor_________

2. Has the pen been inking properly: yes______________ no____________

3. Trouble shoot Mast meter by looking at yesterday's record on the take-up reel of recorder.
   (a) Background concentration of 0 to 0.06 ppm evident at night: yes___ no___
   (b) Daylight concentration exceeds the night background: yes___ no___
   (c) Should Mast meter be replaced: yes___ no___

4. Remove paper weekly: Monday_____________ or Wednesday____________

5. Is there enough paper to last until the next visit_____________.

6. Is the recorder amplifier ON_________________.

7. Is the chart advance ON__________, the proper speed___________.

8. Recheck to be sure that Departure time______________
   Date_______________
   K Factor______________
   are written on chart paper.

Final Procedures

1. Lock the box________________.

2. Take bottle of solution and any chart paper to truck______________.

3. Describe: Temperature: ______________________________________
   (Wet) (Dry)

   Cloud cover: ______________________________________
   (tenths), thunderheads,

   Visibility ______________________________________
   (good) (poor)

   Wind: Speed_______________ Direction____________

Results

Oxidant data was obtained for part of June and all of July, August, and September at each station. Monitoring was continued through October but wet weather and technical difficulties limited the amount of data which was of value for station-to-station comparisons.

Seasonal changes in oxidant concentration -- Variation of daily oxidant maxima during the sample period for all stations is summarized in Figure 2. It is possible to view the changes in daily peak concentrations from day to day during the sample period at a single station or compare the relative peak concentrations on a given day from station to station.

The controlling influence of weather on episodes of high oxidant is readily apparent. For example, June 29 and August 20-22 were dates of the most severe episodes at nearly all stations during the entire sample period. Reference to the summary of southern California weather (Appendix I) shows that the episode in June involved a High pressure system aloft with temperatures in the high 90's to 100 degrees with the top of the marine layer down to 900 ft. During August 20-22, there was a moderate onshore pressure gradient with marine air inland to 4,000 ft. and high pressure aloft. This kind of weather pattern unfortunately is very typical during the summer. On the other hand, a combination of other features kept oxidant concentrations relatively low in the mountains during the last 5 days of August and most of September. Two tropical storms, Gwen on August 29 and Hyacinth on September 5, brought moist air, thunderstorms and much instability to the mountain area. The other influence during September was the repeated occurrence of high pressure systems inland causing an offshore pressure gradient and strong Santa Ana winds which prevented easterly advection of polluted air.

The temperature, dew point, relative humidity, wind speed and direction recorded at each station at the time when technicians performed maintenance on the instruments is included in Appendix II. These data are not useful for further analysis of meteorological trends because the information was not taken at the same time each day but they are helpful for spot checking environmental conditions which accompany oxidant concentrations at that time of day.

Monthly averages of the daily maxima, the number of hours daily that oxidant exceeded .08 ppm (Federal Air Quality Standard), and the single highest daily maximum for each month are presented in Table 1. Because there was missing data at all stations (Figure 2), these averages reflect incomplete but useful trends. Definite gradients of oxidant concentration are indicated along the two west to east transects. But the gradient from Rim Forest to Fawnskin is more prominent than that from Camp Angeles to Heart Bar State Park. The terrain features where the latter stations are located help explain the difference because the transport of polluted air up the Santa Ana drainage basin is unimpeded by any physical barriers. Transport along the other transect is complicated by a much more variable terrain including the main ridge of the mountains with intersecting drainages and the fact that the eastern-most station, Fawnskin, is in a distinct basin not directly comparable with ridgetop sites.

In Figure 1, the numbers superimposed on the terrain map are averages for June through September of the duration (hours) daily when oxidant concentrations exceeded .08 ppm at the six stations. This summary emphasizes the difference between the northern and southern transects and validates the hypothesis that a significant gradient of oxidant exposure exists from west to east across the Forest.

Daily changes in oxidant concentration and duration -- A more detailed analysis of the changes at all six stations is presented in Figure 3 where hourly concentrations for 48 hours are plotted. Again, one is struck by the uniformity in the hourly changes at Camp Angeles, Barton Flats, and Heart Bar. The times of the daily oxidant maxima are nearly identical here as in Figure 4 where the average of hourly concentrations for August 23-26, 1972 are presented. At Heart Bar, the slightly later arrival of oxidant is counterbalanced by a slower decay of ozone after sundown. There is probably less nitric oxide (NO) available at this more remote, higher elevation site to serve as an ozone sink.

A comparison of Rim Forest, Green Valley Lake, and Fawnskin in Figure 3 and Figure 5 (hourly averages for July 1-5, 1972) shows that Rim Forest and Green Valley Lake are under greater influence from South Coast basin air than Fawnskin. Green Valley Lake begins to register the advected oxidant about 4 hours later than Rim Forest in both Figures 3 and 5. Fawnskin (Figure 5) shows a minimal influence from basin air during this period but in the 48-hour period (Figure 3), there is some evidence that the Big Bear basin may have its own unique air pollution problem. On both June 24 and 25, 1972, there appears to be synthesis of oxidant beginning at 0700 plus advection from outside the basin. A radiation inversion may frequently trap polluted air overnight in the basin so that NO_2 and hydrocarbons are immediately available for oxidant synthesis at sunrise.

Comparison of 1972 oxidant at Rim Forest with earlier years -- The trend in oxidant levels as measured by an average of the daily maxima from May through September each year is indicated in Figure 6. The average maxima (pphm) for the 6 months during each year are as follows:

1968	20
1969	18
1970	22
1971	22
1972	22

According to this index, air quality is not improving.

Inclement spring and fall weather have made it difficult to maintain an oxidant monitoring station in the mountains. It is certain that the above data do not reflect the total dosage experienced by forest vegetation each year.

Summary

Oxidant air pollution concentrations were measured continuously from mid-June through September 1972 in the San Bernardino mountains at six stations in a downwind configuration from the polluted South Coast air basin to the west. During this time, the duration of oxidant concentrations above .08 ppm ranged from 12.6 to 5.7 hours thus defining a gradient of oxidant dosage from west to east. The magnitude of this gradient compared well with amounts of damage to coniferous vegetation in nearby plots. These observations also indicate that probably there is no portion of the coniferous forest in the 5,000 to 7,000 ft. zone in the San Bernardino National Forest which does not receive significant exposure to oxidant air pollution. Considerably more sampling will be required to challenge the above statement and to better quantify the dosages received at selected sites. This initial data adequately supports the proposed protocol for a study of the effects of oxidant air pollution on a mixed conifer ecosystem.

Recommendations for Future Work

1. Continue to collect total oxidant data at the same six stations in the following years but improve the quality of the oxidant monitoring instruments by replacing the Mast analyzers with the DASIBI, UV, specific ozone analyzer.

The quality and quantity of data must be improved.

2. At one selected station continuously monitor NO_2, SO_2, and peroxyacetyl nitrate. These instruments could be placed in a trailer (available) and moved from site to site.

3. At all six permanent stations, continuously measure temperature, humidity, wind speed and direction, precipitation, insolation and evaporation.

4. If new equipment (item 1) is available, then older oxidant monitoring instruments can be used to expand the observation network for limited times. It will be desirable to extend the sample transect west of Crestline and east of Big Bear Lake first. Later, observations should be made north of the transect running from west to east.

5. Automate the data acquisition system at the six more permanent stations (item 1) so data will be placed initially on magnetic tape to eliminate the labor and long time required to transfer data from strip charts to punch cards. Share technical skills and costs for establishing and maintaining a base station to receive data by wire or telemetry from the six sensor stations with a U.S. Forest Service project at the Forest Fire Laboratory, Riverside. The Fire Meteorology Project will select and test an automated system as part of their current research in 1973.

6. Cooperate with the San Bernardino County Air Pollution Control District so that the most effective network of monitoring stations can be established and data can be shared.

Table 1. Summary[1] of oxidant data at six San Bernardino Mountain stations-June-September 1972 (pphm).

		Rim Forest	Green Valley Lake	Fawnskin	Camp Angeles	Barton Flats	Heart Bar
June	Average daily max.	20	19	17	19	13	16
	Highest daily max.	37	40	23	32	22	31
	Hrs > 8	9.9	13.3	12.4	6.2	7.6	5.3
July	Average daily max.	23	17	13	19	21	18
	Highest daily max.	39	31	21	27	33	35
	Hrs > 8	11.5	9.0	7.2	7.8	7.6	5.6
Aug.	Average daily max.	25	17	13	21	18	19
	Highest daily max.	45	35	21	46	30	36
	Hrs > 8	17.4	6.0	4.4	9.6	7.9	6.9
Sept.	Average daily max.	20	13	10	16	13	15
	Highest daily max.	31	23	16	28	19	29
	Hrs > 8	11.7	3.3	1.9	6.2	6.2	5.3

[1] Averages do not represent an equal number of days or the same days at each station (see Figure 2).

Appendix I

Summary of Southern California Weather, May-September 1972 (excerpted from the California Fire Weather Reports, U. S. Forest Service).

May 1-10

Southern California experienced above normal temperatures and low humidities. By the 4th, the onshore pressure gradient increased, producing a stronger flow of marine air inland. This lowered the temperatures and increased the humidities all the way into the intermediate valleys. By the 6th, the marine layer had increased to a depth of 5,000 ft. Conditions remained about the same until the 8th when a slow warming and drying trend developed. By the 10th, the upper ridge was just beginning to move onshore to further increase temperatures. The pressure gradient was very weak, but trending offshore. No precipitation occurred for the period and no strong winds were reported.

May 11-20

The period began with a weak offshore pressure gradient. The marine layer was confined mostly to the immediate coast. Temperatures inland were in the upper 80's and relative humidities averaged 20 percent. There were no strong winds. Similar conditions prevailed through the 14th. By the 13th, the San Bernardino area had temperatures up to 100 degrees. Top of the marine layer was around 500 ft. with only coastal fog. Humidities averaged from 10 to 20 percent. A cooling trend beginning on the 15th brought temperatures back to normal. By the 19th, temperatures were in the 30's in mountain areas and the high 50's-low 60's elsewhere. Humidities ranged from 50 to 100 percent. On the 18th, Strawberry Peak had southerly winds of 33 mph and Rock Camp had southeasterly winds of 28 mph on the 19th. No thunderstorms were reported, but precipitation occurred on the 19th and 20th. Total amounts ranged from .05 to an inch, but stations at higher elevations averaged about .3 inch.

May 21-31

Temperatures were in the upper 90's from the 27th on, and relative humidities ranged from 15 to 30 percent. A Low aloft over the southwest coast and Baja California, which persisted from the 27th through the 31st, produced widely isolated thunderstorms in the San Bernardino N.F., but the only measurable precipitation reported for the period was 1.5 inch on the 31st at Converse. Because of the easterly, warm flow during the latter part of the period, areas near the coast reached record breaking temperatures, and the marine layer was either very shallow or nonexistent from the 27th on.

June 1-10

A Low aloft over Baja California brought moisture over the area on the 1st. There were numerous lightning strikes, although the showers were light. On the 2nd and 3rd, there was a weak upper trough off the coast and an upper High over the southwest interior. Scattered thunderstorms persisted on the 2nd, but none on the 3rd. An upper Low over Baja, bringing moist, unstable air into the area, was the dominate feature again from the 4th-7th. Numerous thunderstorms persisted during these 4 days. Precipitation amounts were .93 at Fawnskin and .74 at Converse on the 5th, and from .15 to .35 on the San Bernardino N.F. on the 6th. From the 8th-10th an upper trough off the coast produced a deep marine layer, from 4,000 to 6,000 ft. This kept temperatures cool. By the afternoon of the 10th, however, the trough had weakened and temperatures were up 8 degrees and humidities down 20 percent.

June 11-20

On the 11th, a weak upper-trough was over Baja California and a ridge aloft was moving eastward to the California coast. Pressure gradient was moderately offshore, temperatures were increasing, and relative humidities were down. Winds were from the northeast. Pressure gradient had changed to onshore by the 12th, allowing a shallow marine layer along the coast. A weak upper-trough off the coast caused a deepening of the marine layer on the 13th-15th, and slight cooling occurred. Further deepening of the marine layer, to 3,000 ft. was noted on the 17th and 18th. Slight warming occurred on the 19th, the marine layer was down to 2,000 ft., and humidities were down considerably. On the 20th, an upper Low just off the coast to the southwest produced a moist south-southwest flow. There was a substantial increase in relative humidities, slight decrease in temperatures, and considerable cloudiness. Many thunderstorms occurred in the afternoon on the San Bernardino N.F. The San Bernardino N.F. had less than .33 inch precipitation.

June 21-30

An upper Low off the coast to the southwest produced moist south-southwest flow aloft on the 21st. Thunderstorms were reported on the San Bernardino N.F. and precipitation ranged from .20 to .59 inch on the 21st. A deepening upper trough off the west coast produced a cooling trend on the 22nd with an 18-degree drop in temperatures. On the 22nd, the top of the marine layer increased to 6,000 ft. and widely scattered showers occurred, though very little measurable precipitation was recorded. The trough weakened slightly on the 23rd. On the 26th, the top of the marine layer was around 2,500 ft. A High aloft over the area on the 27th-29th produced warming and drying. Temperatures were in the high 90's to 100 degrees and the top of the marine layer was down to 900 ft. on the 29th. A cooling trend began on the 30th.

July 1-10

A high-pressure system aloft and weak to moderate onshore pressure gradient at the surface were the dominant features for the 10 days. The top of the marine layer varied from 1,000 to 2,500 ft. From the 5th-7th, temperatures at lower elevations reached the 100-degree mark and relative humidities ranged from 10 to 20 percent. But at higher elevations, temperatures were in the upper 90's and relative humidity from 8 to 15 percent for these three days. No strong winds or thunderstorms occurred.

July 11-20

For the first 3 days of the period, temperatures were over the 100-degree mark in the valleys and the high 80's-low 90's in the mountains. Pressure gradient was weak, and marine air did not penetrate inland. An increase of onshore flow on the 14th caused a decrease in temperatures in the low levels. This trend of increasing onshore pressure gradient and decreasing temperatures continued through the 19th, when the pressure gradient between Los Angeles and Tonopah was 13.2 mb. A deep upper trough over the western U.S. on the 20th caused the marine layer to deepen to 5,000 ft. Temperatures became very low for this time of the year. Valley stations had high readings in the low 80's; in the mountains, Fawnskin reached 72 degrees. Winds through the passes averaged 20 to 30 mph from the southwest on the 17th-19th.

July 21-31

The area was under the influence of a weak trough aloft for the first 4 days and a weak upper High from the 25th on. Top of the marine layer was 4,500 ft. on the 21st, 2,000 ft. on the 22nd, and marine air was practically nonexistent inland for the remainder of the period. Temperatures were above normal for most of the period. On the 30th, for example, coastal slopes had from 100-107 degrees and higher elevations were in the low 90's. A few thunderstorms were reported on the Cleveland N.F. on the 28th, but on the 29th and 30th they became more widespread reaching all the forests. Except for winds associated with the thunderstorms, strong winds were reported at Fawnskin, southeast at 31 mph on the 31st.

August 1-10

Marine air, with the top from 2,000 to 3,500 ft., kept temperatures cool for the first 3 days. Inland valleys had high temperature readings in the mid-80's on the 3rd, and relative humidities averaged 40 percent in the mountains and 35 percent at lower levels. By the 6th, a warming trend brought inland temperatures to the 100-degree mark. Moist southeast flow aloft kept humidities relatively high and produced isolated thunderstorms on the San Barnardino N.F. on the 4th-8th and again on the 10th. Precipitation at Big Bear was .27 inch on the 5th. The city of San Bernardino reported .08 inch on the 10th. Except for areas of thunderstorms, winds were exceptionally light because of a weak pressure gradient.

August 11-20

On the 11th, the area was under the influence of a High aloft over southwestern U.S. The weather pattern changed abruptly on the 12th. A Low aloft just off the coast of Baja California brought moist, unstable air to the area. Areas from the Los Padres N.F. southward received some precipitation. Kenworthy on the San Bernardino N.F. received 1 inch of rain and areas along the coast, including Los Angeles, had up to .33 inch. Temperatures were in the high 60's to high 70's. From the 13th on, a trough aloft off the west coast produced a drier southwest flow aloft. Except for the 15th-17th, there was a fairly moderate onshore pressure gradient with marine air inland to 4,000 ft.

August 21-31

High pressure aloft was the dominant feature for the first 3 days, whereas low pressure aloft influenced weather in the area for the remainder of the period. An upper-level trough developed over southern California on the 24th, and persisted in the area through the 28th. The dominant feature from the 29th on was a low pressure area called tropical storm Gwen, which was off the coast of central Baja California on the 29th. A moderate offshore pressure gradient existed on the 22nd. At lower elevations, temperatures were over 100 degrees and humidities were low. By the 24th, the pressure gradient was moderate onshore, and the top of the marine layer was at 4,000 ft. Widely scattered thunderstorms occurred on the 27th, 29th, and 31st. Precipitation amounts were light and the storms were confined to the San Bernardino and Cleveland National Forests on the 31st.

September 1-10

The period was exceptionally cool and cloudy as a result of low pressure aloft. At the beginning of the period, a weak Low was just off the southwest coast. There was a moderate onshore pressure gradient. South-southeasterly flow aloft produced widely scattered showers and thunderstorms on the 2nd on the San Bernardino N.F. Precipitation amounts on the 3rd ranged from .02 to .13 inch and temperatures were from the low 80's in the valleys to the mid-70's at mountain stations. Relative humidities were around 40 percent at low levels and over 50 at higher elevations. This same trend continued on the 4th with scattered showers. On the 5th, increased moisture, because of tropical storm Hyacinth, produced widespread showers and thunderstorms. By the 6th, Hyacinth had dissipated, though there was still enough moisture in the area to produce scattered thunderstorms. From the 7th on, the area was under the influence of a deepening trough along the coast. This resulted in a very deep marine layer and cooler temperatures.

September 11-20

A deep trough aloft off the west coast produced a strong onshore pressure gradient with the top of the marine layer at 7,000 ft. on the 11th. The cyclonic flow aloft weakened on the 12th, when temperatures increased slightly. Weak low pressure aloft continued for most of the period. There was very little change on the 13th through the 16th except for minor variations in humidities and depth of marine layer. On the 19th, top of the marine layer was 3,500 ft. On the 20th, an upper-level ridge moved into the area. A surface high pressure area over Montana produced moderate offshore pressure gradient and a moderate Santa Ana condition. Strong winds were generally confined to the higher peaks and ridges. Butler Peak had northeast winds to 50 mph.

September 21-30

The period began under a dying Santa Ana condition. Temperatures ranged from 100 degrees in the low levels to 85 degrees at higher elevations. Relative humidities were 8 to 18 percent. Maximum winds recorded at national forest stations were northeast 23 mph. A strong upper trough moved into the Pacific Northwest on the 22nd, and conditions remained hot and dry. By the 23rd, a cooling trend began as the upper trough deepened and moved over the western U.S. This condition persisted through the 28th. Top of the marine layer varied from 2,000 ft. on the 23rd to 5,000 ft. on the 25th and 26th. On the 29th, a surface High built rapidly over the Plateau and produced a short-lived moderate Santa Ana condition. Maximum winds occurred the morning of the 29th; maximum pressure difference between Los Angeles and Tonopah was -7 mb. By the 30th, there was still a moderate offshore pressure gradient producing high temperatures and low humidities.

Appendix II

DATE	STATION	TIME	DB	DP	% HUM.	WS	WD
June 26	RF	0920	--	--	--	2	NE
	GVL	1005	75	--	--	1	E
	FS	1200	75	--	--	1	E
	CA	1400	72	--	--	3	NE
	BF	1330	76	--	--	1	E
	HB	1315	72	--	--	2.5	E
June 28	RF	0935	77	35	20	0	--
	GVL	1050	80	37	16	0	--
	FS	1200	85	38	6	0	--
	CA	1353	87	39	15	0	--
	BF	1320	90	42	15	0	--
	HB	1252	86	31	8	0	--
June 30	RF	0950	88	53	20	0	--
	GVL	1100	90	42	15	0	--
	FS	1200	93	42	12	0	--
	CA	1340	93	44	15	0	--
	BF	1300	90	42	15	2.5	NW
	HB	1240	92	37	10	0	--
July 3	RF	1039	82	44	24	6	S
	GVL	1206	80	37	16	0	--
	FS	1308	92	45	15	4	S
	CA	1617	81	39	18	0	--
	BF	1532	78	33	15	5	NW
	HB	1430	82	35	15	6	NW
July 5	RF	1000	--	--	--	-	--
	GVL	--	--	--	--	-	--
	FS	1400	--	--	--	3	NE
	CA	1615	84	42	19	0	--
	BF	1547	82	41	18	0	--
	HB	1500	80	40	16	3	SW
July 10	RF	1040	80	48	35	0	--
	GVL	1150	86	45	20	0	--
	FS	1240	84	55	31	0	--
	CA	1550	84	51	26	0	--
	BF	1535	80	45	25	6	N
	HB	1512	80	49	30	0	--

DATE	STATION	TIME	DB	DP	% HUM.	WS	WD
July 12	RF	1215	95	53	22	0	--
	GVL	1050	83	47	25	0	--
	FS	1000	78	39	20	0	--
	CA	0850	73	46	33	0	--
	BF	0842	78	46	28	0	--
	HB	0915	79	41	20	0	--
July 14	RF	0940	85	44	22	0	--
	GVL	1105	94	44	14	4	SW
	FS	1205	95	37	10	0	--
	CA	1340	--	--	--	-	--
	BF	1320	76	45	30	0	--
	HB	1305	--	--	--	-	--
July 17	RF	1235	79	46	30	8	W
	GVL	1325	83	51	29	4	E
	FS	1435	85	48	24	0	--
	CA	1615	78	52	37	0	--
	BF	1600	75	48	35	0	--
	HB	1520	80	42	22	8	NW
July 20	RF	0900	58	50	75	0	--
	GVL	1045	70	36	22	0	--
	FS	1025	68	36	22	0	--
	CA	1330	76	50	35	0	--
	BF	1300	76	52	35	0	--
	HB	--	--	--	--	-	--
July 26	RF	1215	85	38	20	3	SW
	GVL	1315	82	43	25	3	SW
	FS	1410	85	41	19	4	W-SW
	CA	1630	81	44	23	4	W-SW
	BF	1550	81	39	19	3	W-SW
	HB	1535	80	37	19	3	W-SW
July 28	RF	1640	82	46	28	3	SW
	GVL	1535	81	50	31	10	SW
	FS	1415	84	44	22	3	SW
	CA	1105	91	19	24	2	SW
	BF	1125	87	46	22	3	SW
	HB	1255	83	49	27	6	S

DATE	STATION	TIME	DB	DP	% HUM.	WS	WD
July 31	RF	1230	97	58	35	9	SW
	GVL	--	--	--	--	-	--
	FS	1130	81	50	29	0	--
	CA	0930	82	52	30	0	--
	BF	1005	85	56	35	0	--
	HB	1030	81	50	29	0	--
Aug. 2	RF	1000	78	42	20	0	--
	GVL	1100	78	39	22	0	--
	FS	1200	80	42	22	0	--
	CA	1355	80	40	24	3	SW
	BF	1320	78	42	24	3	NE
	HB	1300	80	37	17	5	SW
Aug. 4	RF	1015	79	39	20	5	W
	GVL	1319	83	47	25	0	--
	FS	1206	83	45	22	0	--
	CA	1015	79	41	20	5	W
	BF	1035	78	44	25	3	W
	HB	1103	79	38	20	5	S
Aug. 7	RF	1525	79	56	45	4	SW
	GVL	1255	--	--	--	3	SW
	FS	1200	77	55	44	7	SW
	CA	1000	75	61	57	3	SE
	BF	1035	78	59	48	3	SE
	HB	1115	81	60	45	5	NE
Aug. 9	RF	1525	80	52	37	0	--
	GVL	--	--	--	--	-	--
	FS	1425	79	52	52	0	--
	CA	1005	74	53	40	0	--
	BF	1105	79	55	54	0	--
	HB	1150	81	48	50	4	S
Aug. 11	RF	1515	77	54	50	0	--
	GVL	1425	78	64	60	0	--
	FS	1250	83	45	18	7	SW
	CA	1038	81	58	43	0	--
	BF	1110	78	56	45	6	NW
	HB	1150	77	55	43	8	NW

DATE	STATION	TIME	DB	DP	% HUM.	WS	WD
Aug. 15	RF	1510	73	39	28	12	SW
	GVL	1405	83	31	18	0	--
	FS	1305	78	30	13	6	SW
	CA	0940	65	31	20	0	--
	BF	1035	75	19	15	4	NW
	HB	1155	71	26	15	4	NW
Aug. 18	RF	1430	69	47	45	12	S
	GVL	1235	76	36	19	6	SW
	FS	1125	75	27	13	4	SW
	CA	0920	63	38	35	0	--
	BF	0940	65	31	28	3	N
	HB	1000	66	29	20	6	NW
Aug. 21	RF	1345	82	38	19	7	S
	GVL	1230	84	26	9	0	--
	FS	1103	81	33	13	0	--
	CA	0930	74	32	15	0	--
	BF	0955	76	41	24	0	--
	HB	1015	75	42	25	6	SW
Aug. 23	RF	1340	84	26	19	11	S
	GVL	1240	86	42	19	0	--
	FS	1140	91	35	10	3	SW
	CA	1000	77	35	16	0	--
	BF	1020	82	32	18	0	--
	HB	1050	81	30	12	4	SE
AUG. 25	RF	1330	72	49	54	7	S
	GVL	1230	83	45	23	0	--
	FS	1125	76	41	24	7	SW
	CA	0940	71	38	25	5	S
	BF	1020	71	43	31	5	NE
	HB	1035	68	43	40	7	SE
Aug. 28	RF	1330	80	48	30	4	S
	GVL	1235	76	43	23	4	NE
	FS	1125	73	41	28	0	--
	CA	0940	71	38	25	5	S
	BF	1010	70	41	30	3	E
	HB	1035	66	44	41	4	SE

DATE	STATION	TIME	DB	DP	% HUM.	WS	WD
Aug. 30	RF	1350	76	56	48	10	S
	GVL	1245	70	55	50	0	--
	FS	1150	72	50	44	0	--
	CA	1000	75	52	42	0	--
	BF	1035	74	53	44	0	--
	HB	1050	73	52	44	6	SE
Sept. 1	RF	1235	82	39	20	12	S
	GVL	1135	73	39	24	5	E
	FS	1045	82	38	16	4	SW
	CA	0840	67	37	28	0	--
	BF	0915	71	35	20	0	--
	HB	0955	72	39	25	4	W
Sept. 4	RF	0705	67	53	57	0	--
	GVL	0742	62	49	60	0	--
	FS	0835	65	49	80	0	--
	CA	1045	74	56	50	0	--
	BF	1005	68	56	63	0	--
	HB	0945	68	51	50	0	--
Sept. 6	RF	1515	64	58	80	3	S
	GVL	1130	63	49	55	0	--
	FS	1037	60	49	64	5	SW
	CA	0915	60	55	85	0	--
	BF	0936	62	49	60	0	--
	HB	0954	60	47	59	0	--
Sept. 8	RF	0930	64	43	44	5	S
	GVL	1015	75	31	15	0	--
	FS	1115	76	36	18	7	S
	CA	1255	72	56	53	0	--
	BF	1235	71	54	52	0	--
	HB	1205	71	54	52	0	--
Sept. 11	RF	0940	54	51	76	10	S
	GVL	1030	59	23	18	5	E
	FS	1125	73	13	9	5	S
	CA	1305	64	44	45	2	S
	BF	1245	61	44	49	0	--
	HB	1215	64	35	29	7	W

DATE	STATION	TIME	DB	DP	% HUM.	WS	WD
Sept. 13	RF	0935	64	33	30	3	S
	GVL	1020	67	21	10	3	E
	FS	1120	81	22	5	3	S
	CA	1300	74	35	20	4	S
	BF	1235	74	35	20	10	NW
	HB	1210	77	24	9	9	SE
Sept. 15	RF	0930	69	17	25	10	S
	GVL	1010	68	23	10	5	NE
	FS	1055	79	29	10	3	SW
	CA	1430	80	37	18	0	--
	BF	1410	80	37	18	0	--
	HB	1145	76	33	15	4	SE
Sept. 18	RF	1235	73	55	50	10	S
	GVL	1150	64	50	55	10	SW
	FS	1050	73	29	30	0	NE
	CA	0915	64	52	61	4	W
	BF	0940	62	51	65	0	--
	HB	1005	67	41	30	5	E
Sept. 20	RF	1155	70	35	23	5	S
	GVL	1100	72	20	8	7	NE
	FS	1020	73	27	12	4	S
	CA	0840	63	27	18	5	W
	BF	0915	62	21	15	5	E
	HB	0935	64	22	12	4	SE
Sept. 22	RF	1310	81	27	10	12	S
	GVL	1230	73	27	12	4	E
	FS	1120	71	29	15	4	S
	CA	--	--	--	--	-	--
	BF	1015	70	27	15	0	--
	HB	1040	71	22	10	4	NW
Sept. 25	RF	1430	70	47	40	6	S
	GVL	1145	71	29	16	0	--
	FS	1235	77	28	10	7	SW
	CA	1630	70	48	40	6	S
	BF	1335	66	38	30	5	SW
	HB	1320	71	35	20	8	W

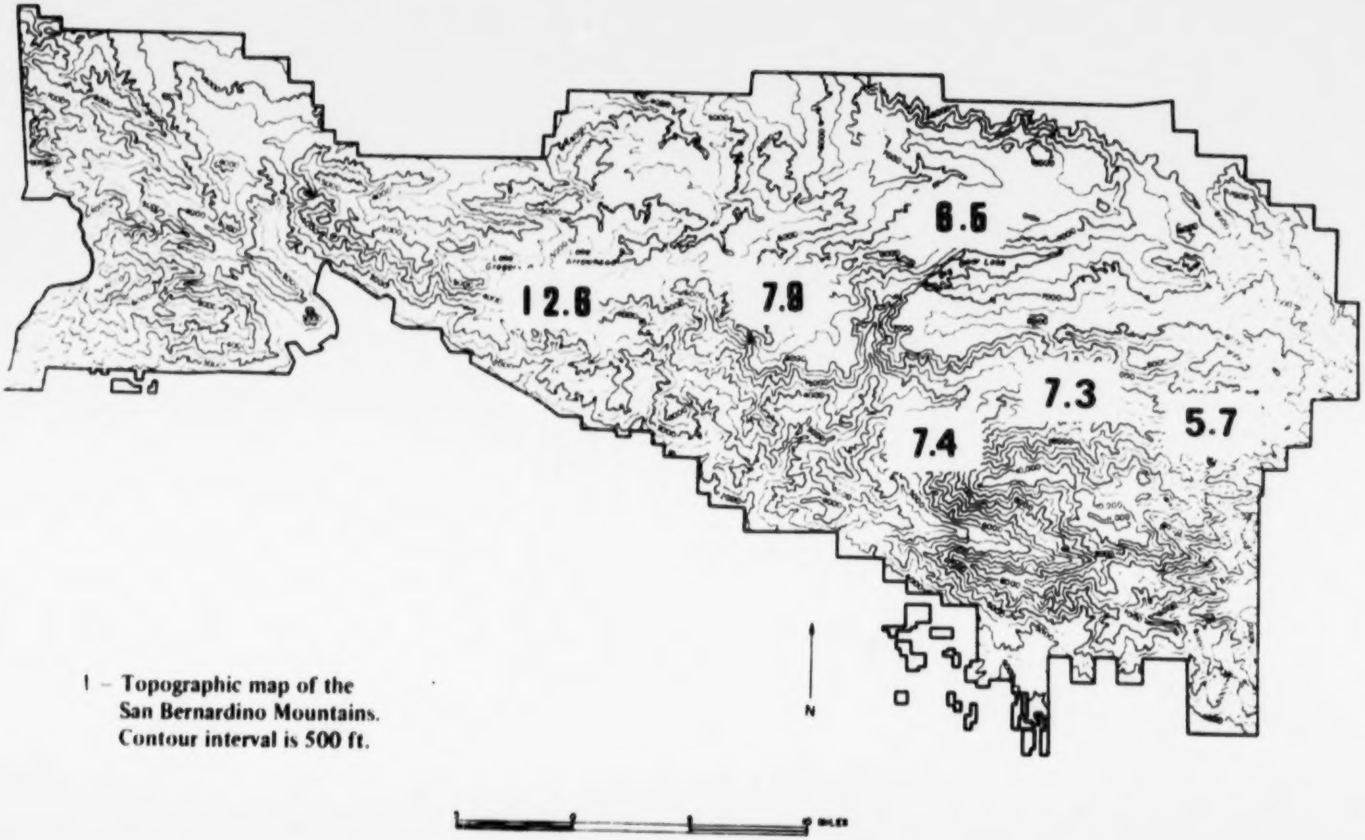
DATE	STATION	TIME	DB	DP	% HUM.	WS	WD
Sept. 27	RF	1135	73	42	3	10	S
	GVL	1050	64	32	25	4	W
	FS	1005	71	35	20	4	S
	CA	0815	53	34	44	0	--
	BF	0845	52	35	45	0	--
	HB	0915	62	28	20	0	--
Sept. 29	RF	1235	79	49	30	5	S
	GVL	1150	73	39	24	5	NW
	FS	1105	74	35	20	4	S
	CA	0915	67	37	27	0	--
	BF	0935	68	36	24	3	W
	HB	1010	67	37	27	5	S
Oct. 2	RF	1320	55	46	65	7	SE
	GVL	1030	52	27	30	0	--
	FS	0945	53	22	25	0	--
	CA	0814	46	41	80	0	--
	BF	0845	43	33	70	0	--
	HB	0905	48	29	44	0	--
Oct. 4	RF	1315	66	50	54	5	NE
	GVL	1240	66	35	25	8	S
	FS	1155	60	34	30	8	SE
	CA	1010	56	44	61	4	SE
	BF	1035	55	39	30	8	SE
	HB	1105	58	31	3	5	W
Oct. 6	RF	1225	70	47	40	6	S
	GVL	1125	65	45	45	9	SE
	FS	1040	60	43	49	7	S
	CA	0930	65	41	35	0	--
	BF	0950	64	46	47	10	NW
	HB	1000	62	45	50	7	NW
Oct. 9	RF	1110	53	48	75	4	S
	GVL	1020	51	49	88	4	S
	FS	0935	57	43	55	4	S
	CA	0810	52	49	86	0	--
	BF	0835	53	46	75	0	--
	HB	0855	51	44	75	5	NW

DATE	STATION	TIME	DB	DP	% HUM.	WS	WD
Oct. 11	RF	1320	71	39	28	9	S
	GVL	1240	66	29	19	7	SE
	FS	1150	65	20	10	4	SW
	CA	1022	63	27	18	3	W
	BF	1050	61	23	18	5	W
	HB	1105	65	24	15	9	S
Oct. 13	RF	0940	59	43	53	14	S
	GVL	1030	56	35	40	12	E
	FS	1155	62	41	42	10	SE
	CA	1330	63	40	40	11	SW
	BF	1305	64	46	48	9	NW
	HB	1245	73	41	27	3	N
Oct. 16	RF	--	--	--	--	-	--
	GVL	--	--	--	--	-	--
	FS	--	--	--	--	-	--
	CA	0955	54	27	30	5	S
	BF	1030	54	16	70	0	--
	HB	1100	51	18	22	5	SW
Oct. 18	RF	1245	48	44	85	9	S
	GVL	1200	47	40	73	7	SE
	FS	1100	55	36	45	0	--
	CA	0930	51	42	69	0	--
	BF	0950	47	42	80	0	--
	HB	1005	46	39	74	0	--
Oct. 20	RF	1305	45	43	95	8	N
	GVL	1220	43	43	90	0	--
	FS	1125	42	38	85	1	S
	CA	0945	51	44	88	2	SW
	BF	1006	47	43	85	0	--
	HB	1030	41	37	85	8	N

Appendix III

Precipitation at Lake Arrowhead Fire Station, 1943-1971

1943	61.08
1944	49.82
1945	51.42
1946	59.65
1947	14.75
1948	28.98
1949	49.78
1950	23.24
1951	38.78
1952	59.08
1953	14.66
1954	50.67
1955	29.60
1956	25.82
1957	40.63
1958	43.07
1959	24.34
1960	32.14
1961	19.50
1962	32.90
1963	32.54
1964	30.54
1965	67.19
1966	38.01
1967	55.87
1968	20.06
1969	98.54
1970	34.61
1971	33.80
Mean =	40.04
Standard Deviation =	18.05


12.6
7.8
6.6
7.4
7.3
5.7
N
MILES

1 – Topographic map of the San Bernardino Mountains. Contour interval is 500 ft.

Figure 1. Number of hours daily when oxidant exceeded 8 pphm at six stations, June-September 1972

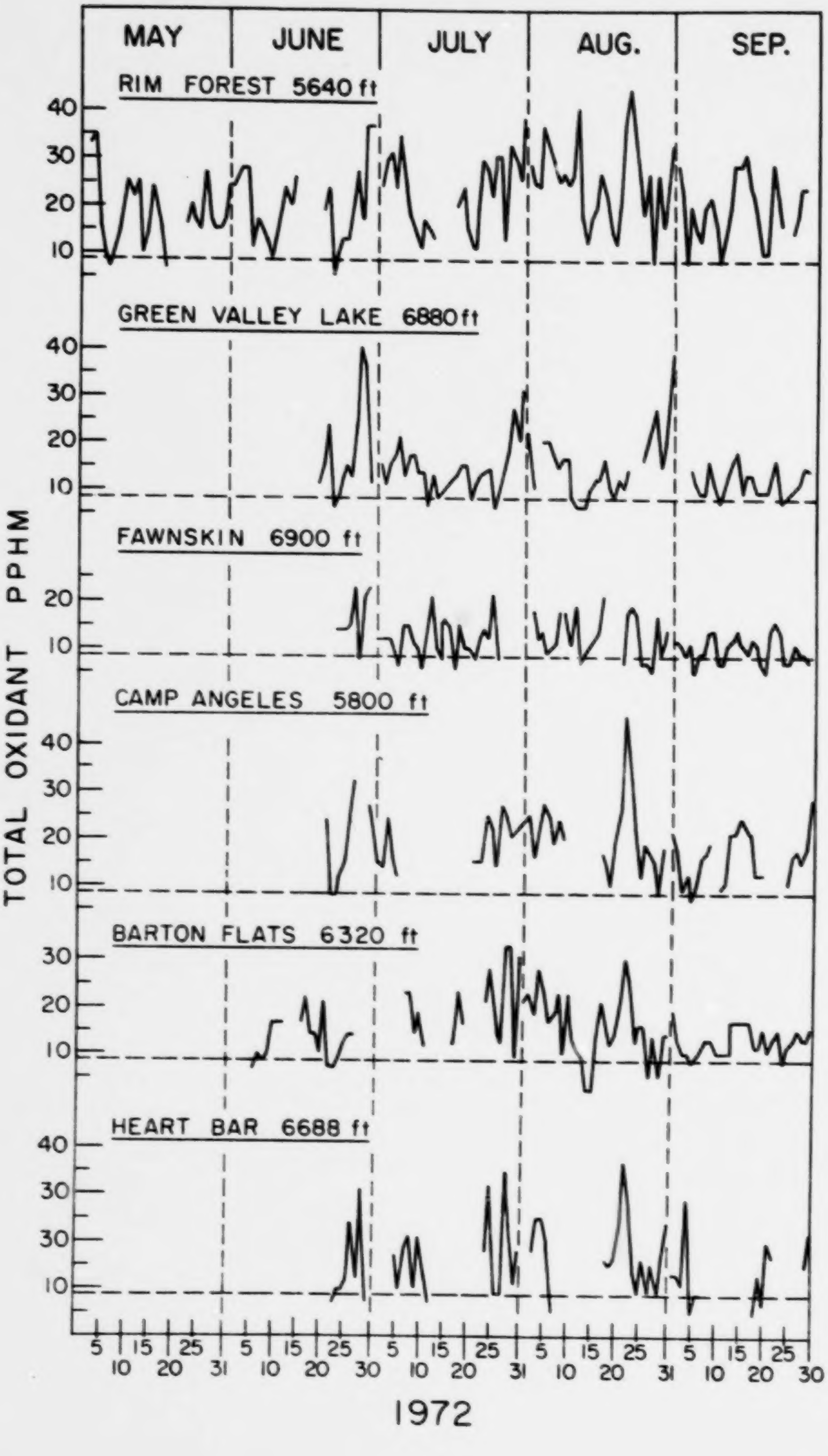


Figure 2. Daily oxidant maxima at six stations are related

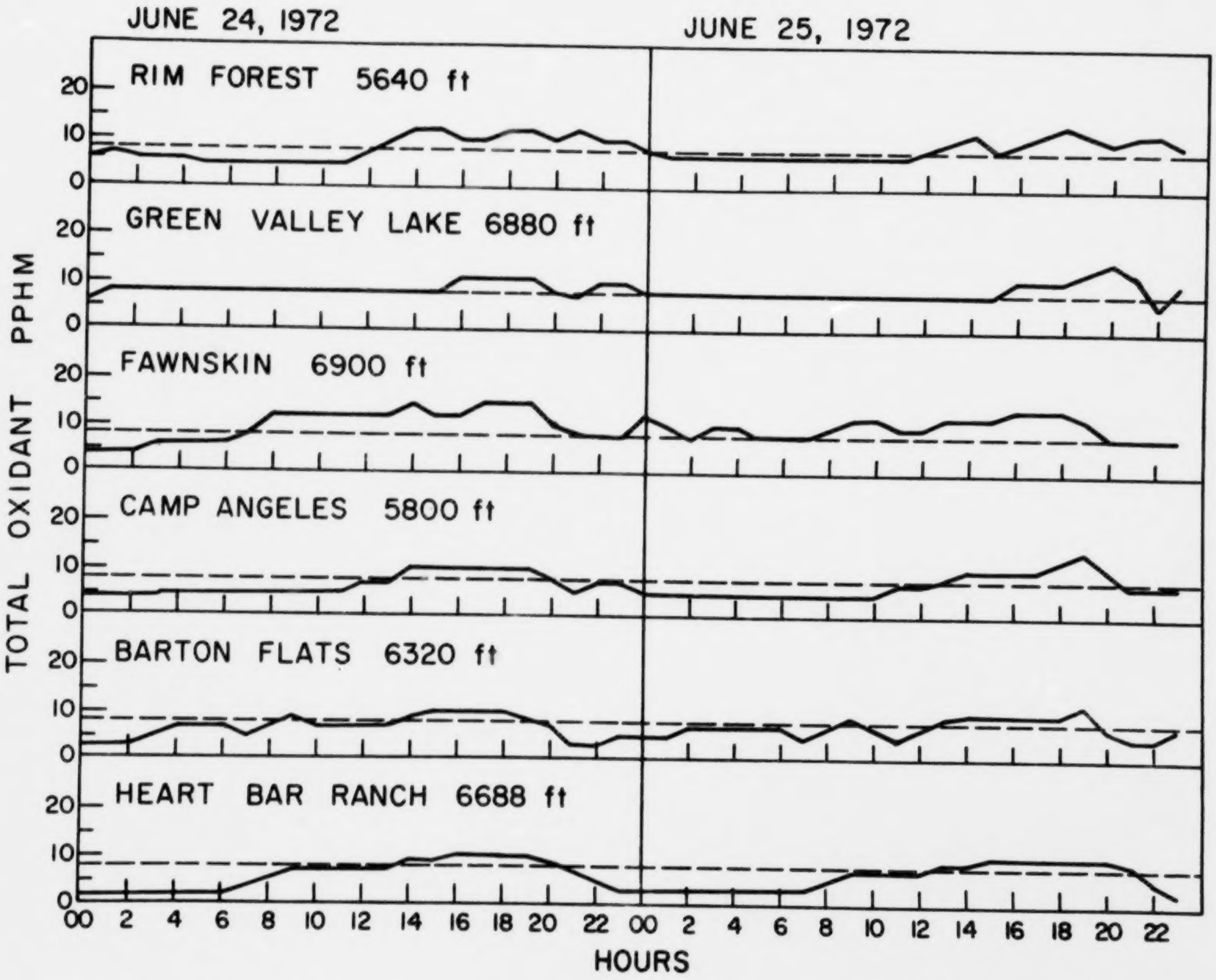


Figure 3. A 48 hour record of oxidant concentrations reveals the mechanism of oxidant transport

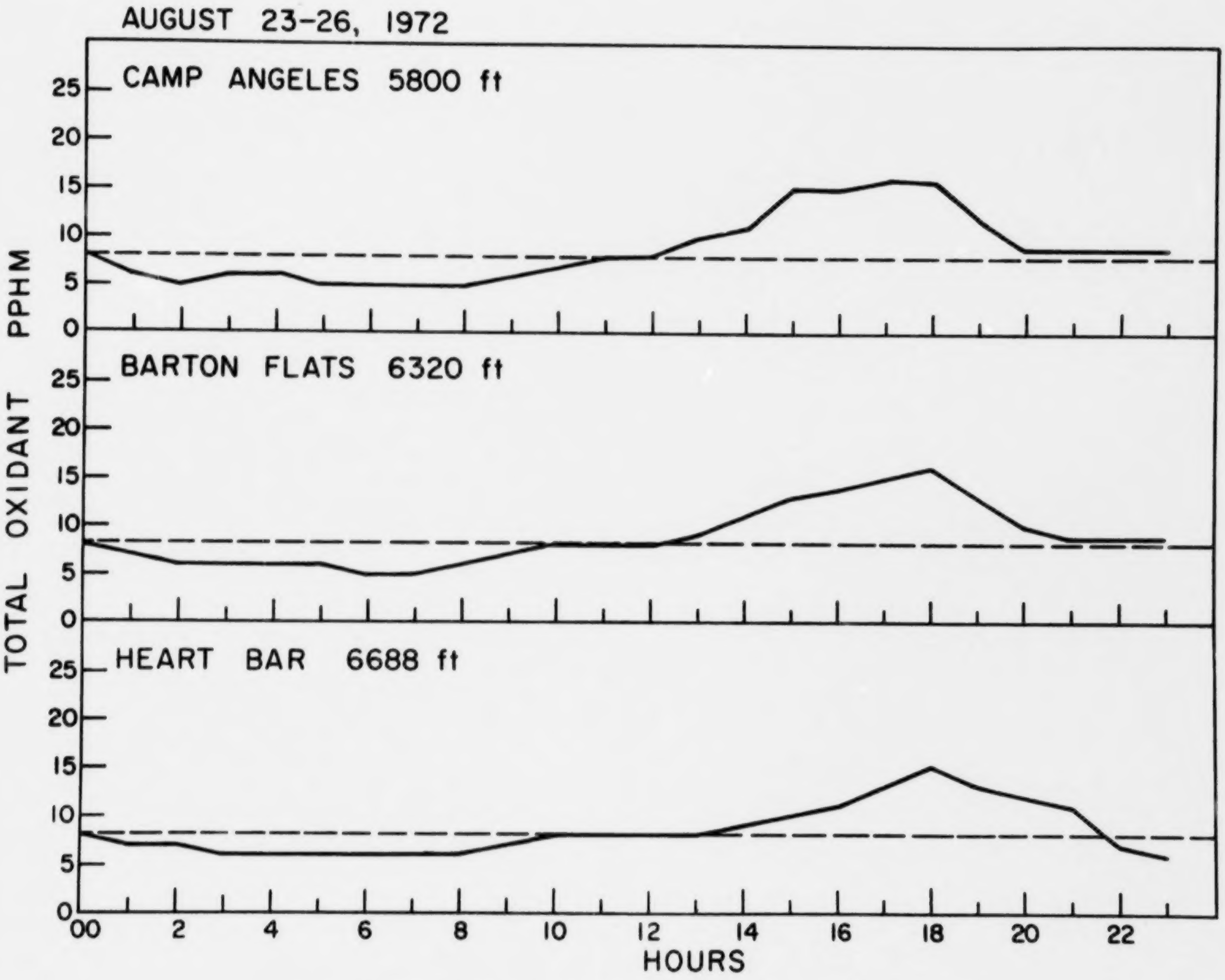


Figure 4. Transport of oxidant eastward along the Barton Flats transect is uninterrupted by terrain

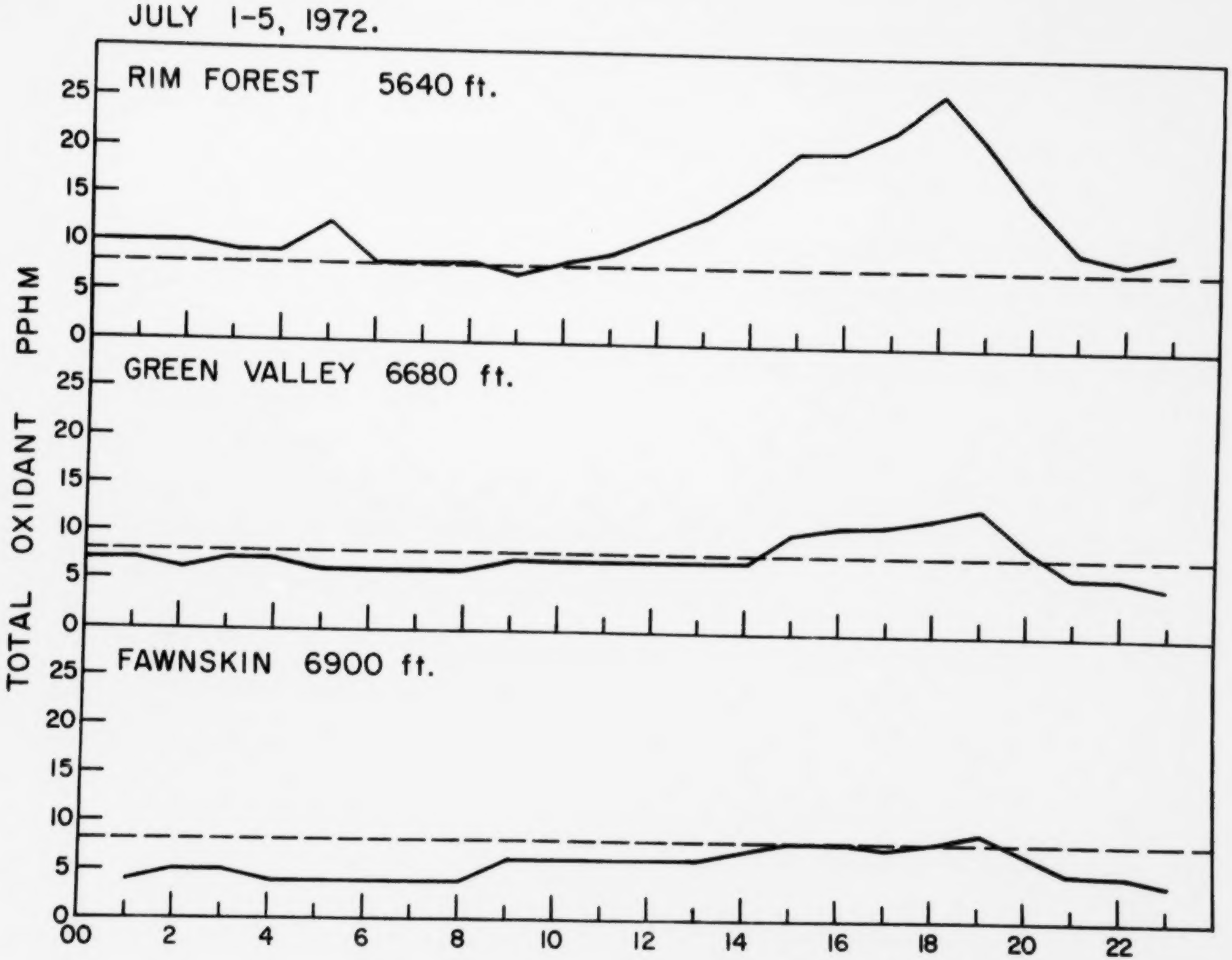


Figure 5. Transport of oxidant eastward along the Lake Arrowhead transect is not uniform because of complex terrain

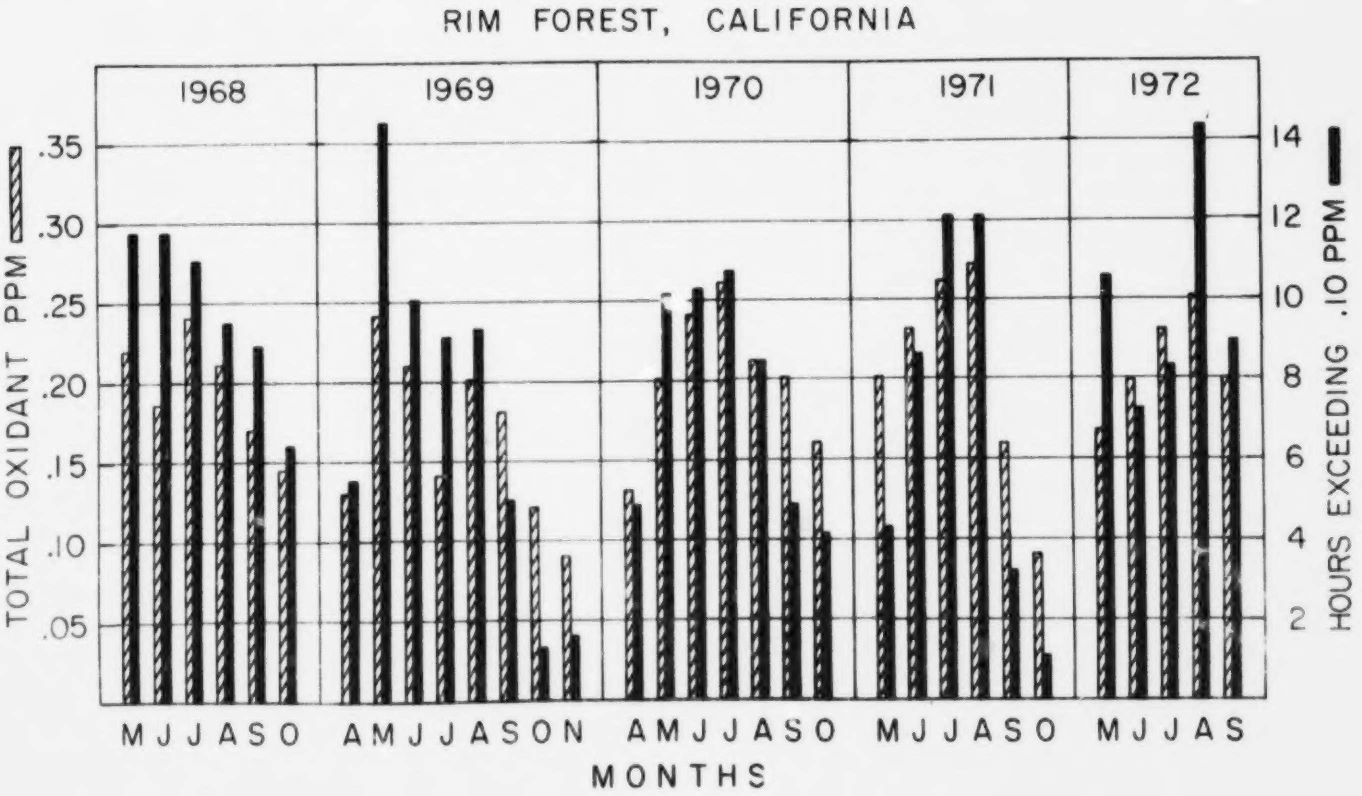


Figure 6. Seasonal trends in oxidant concentration and duration do not reflect improvement from 1968 to 1972

Section VII

A survey of terrestrial vertebrates in the mixed conifer portion of the San Bernardino Mountains

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and

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This report represents a summary of a survey conducted during the summer of 1972 by the authors as the Terrestrial Wildlife Committee's contribution to Task C of the overall "Study of the Effect of Air Pollution on Forest Ecosystems," directed by O. Clifton Taylor, Statewide Air Pollution Research Center, University of California, Riverside 92502.

Abstract - This paper summarizes the research findings of the Terrestrial Vertebrate Committee studying the effects of oxidant air pollution on the forest ecosystem of the San Bernardino Mountains during the summer of 1972. Task C involved field work to obtain current information about the ecosystem in specific plots chosen to be representative of substantial areas. The primary goal of this portion of the study was to inventory the vertebrates present on the study plots. Six study plots were chosen to coincide with the six study plots established by the plant pathology group.

The study focused primarily on three important groups of vertebrates: common resident birds, mammals, and amphibians and reptiles.

A list of the birds found on the six study plots was prepared and the relative population densities were determined using techniques modified from Emlen (1971). A tentative checklist of the birds which may be expected to be found in the coniferous forests of the San Bernardino Mountains was also prepared. In all, some 57 species were observed, from a theoretical list of 86 species. Eight species of birds were found on all six plots. Some of these eight species could serve as focus for studies designed to show the effects of different levels of oxidant air pollution on the avifauna of the mountains.

The common small mammal species present on the six study areas were determined via standard "Calhoun line" procedure. Field and lab work were accompanied by a brief literature search. Brush mice, deer mice, Merriam chipmunks, and meadow mice were common and are likely candidates for detailed study. Permanent markers were established for future studies of the small mammal populations. Sex ratios of the captured species were

determined. An interesting pattern was seen in both the number of individuals captured per plots and in the number of species captured per plot. It appears possible that increasing oxidant air pollution damage is coupled with a decreasing number of species and a decreasing number of individuals captured.

The species of larger mammals likely to be present on the six study plots was determined. Larger mammal species were viewed in terms of suitability for use as indicators of changes in the forest ecosystem due to oxidant air pollution. It was suggested that the western gray squirrel because of its relative abundance, the size of its home range, the ease of observation, and its heavy dependence upon food from the principal trees of the mixed conifer type would be a good candidate for more intensive study.

The reptile and amphibian species likely to be present on the six study plots and their relative abundance, where known, were determined. One of the two heavy oxidant air pollution damage study plots was found to have significantly more lizards than any of the other plots.

A proposal for future research is attached to this report.

INTRODUCTION

For convenience the mixed coniferous forest ecosystem may be viewed as consisting of several major components: inorganic substances, organic compounds, climate regime, producers, macroconsumers, and microconsumers (Odum 1971). It is known that when one part of an ecosystem or community changes, the intimate nature of the internal relations within the ecosystem or community causes changes in the other parts. This report is concerned with macroconsumers, vertebrate organisms which are directly or indirectly dependent on producers (vegetation) for sustenance, and with the possibility of macroconsumer change due to changes within the forest ecosystem because of increasing levels of oxidant air pollution.

The following data were gathered as part of Task C, the final step of the protocol study of the effects of oxidant air pollution on the forest ecosystem of the San Bernardino Mountains. Task B of the protocol study involved the preparation of a report on the background and historical information available for the vertebrate populations of the San Bernardino National Forest. Material for the report was gathered from library publications, reports and notes from archives, and through consultation with individuals who have recorded observations in the area. Task C is the logical sequel to a historical review. Task C involves field work to obtain current information about the ecosystem in specific plots chosen to be representative of the oxidant air pollution effected areas.

The primary goal of this portion of the study was to inventory the vertebrates present on the study plots. Six study plots were chosen to coincide with those established by the Plant Pathology

Committee. Our study focused primarily on three important groups of common vertebrate species: resident birds, mammals, and amphibians and reptiles.

The principal objectives of the study of common resident birds were: to prepare a list of the common species found on each of the plots, to determine population densities and sex and age composition when possible, and to assess the general health and vigor of key populations. Work included both field observations and a search of published and unpublished material useful in preparation of a written summary of the findings.

Extensive field observation of small mammals was accompanied by a cursory literature search. Aside from elaborating which small mammal species were present on the study plots, determination of population densities and sex and age composition were primary goals of this research. Description of any pathology, assessment of the general health and vigor of the populations, and comparison of the results from the six different areas were also stated objectives.

Field observations of the larger mammals were more restricted. Primary objectives for this portion also revolved around making a list of species likely to be resident in the mixed conifer zone of the San Bernardino mountains. Suitability of the various larger mammal species as potential indicators of oxidant air pollution damage was also examined.

Cursory field observations and literature search regarding the reptile and amphibian populations were also undertaken after arrival on the site.

The last fundamental objective for this section of the Task C phase of the protocol study was to provide sufficient recommendations to direct the course of future work. Promising courses of investigation and pressing needs for study are noted. Future studies should build upon the data collected in the performance of this task. This summary is based upon data collected by Kolb during a period of approximately one month of field work.

ACKNOWLEDGEMENTS:

No study such as this is the product of a single person's endeavors. As such, it is only fitting to acknowledge those without whom this study would not have reached fruition. Special thanks go to Mary Kay Kolb, who spent matching time with James in the field recording and making observations and generally serving sundry needs for which she proved invaluable. Acknowledgement must also go to Eugene A. Cardiff for much valuable help, especially on the bird censusing; O. Clifton Taylor, Associate Director, Statewide Air Pollution Research Center; Jerome T. Light, Jr., Wildlife Biologist with the San Bernardino National Forest; Paul Miller, of the University of California, Riverside and the Pacific Southwest Forest and Range Experiment Station; and the staffs of the Forest Supervisor's Office in San Bernardino, the Arrowhead Ranger District Office at Rim Forest, and the San Gorgonio Ranger District Office at Mill Creek, and to the members of the other Committees making up this study group.

DESCRIPTION OF STUDY AREAS

All six study plots were located in the San Bernardino Mountain area of the San Bernardino National Forest. The plots at Rim Forest (Dogwood)

Snow Valley, and Sand Canyon were located on roads originating at State Highway 18. The plots at Heart Bar, Barton Flats (Boy Scout Camp), and Camp Angelus were all off of State Highway 38.

The study plot at Rim Forest was located in Section 21, near the border of Section 28, T.2N, R.3W, Redlands Quadrangle. It was about 2 miles by road ENE of Rim Forest Ranger Station.

The Snow Valley study plot was located in Section 25, T.2N, R.2W, Redlands Quadrangle, about 5½ miles NE of Deer Lick Station.

The Sand Canyon plot was about 4½ miles SE of the Moonridge turnoff of State Highway 18 in Section 36, T.2N, R.1E, Lucerne Valley Quadrangle.

The Heart Bar study plot was located in Section 26, T.1N., R.2E., San Gorgonio Mountain Quadrangle, approximately 1½ miles SE of Heart Bar State Park Campground.

The Barton Flats study plot was about 5 miles NE of the town of Camp Angelus, California, in Section 17, T.1N., R.1W., San Gorgonio Quadrangle.

The Camp Angelus study plot was located in Section 27, R.1N., R.1W., San Gorgonio Quadrangle about ¼ mile south of Camp Angelus Station.

Vegetation

All six study plots were located in the mixed conifer type typical of the San Bernardino mountains. The tree and shrub species found on each of the six plots, along with the approximate extent of crown coverage found in the vicinity of the Calhoun lines, are shown on maps, 1-6, filed with the raw data from this summary. Percent crown cover (including area covered by the shrub layer) was sampled from 10 - 20 percent of map area by using a plastic dot grid randomly thrown on the map. The approximate crown cover and species mix so determined are given in Tables I and II.

BIRDS

The purpose of this phase of study was to prepare a species list of the birds found on the six study plots, and to estimate relative population densities.

Procedures

We used a bird census procedure modified from that outlined by Emlen (1971). One transect per plot was placed in such a manner that it incorporated the area sampled for small mammals. The bird transect routes bisected the study plots mostly along straight lines, although existing trails were used when convenient. The transect routes were flagged with red surveyor's tape to facilitate location. The length of the transects varied slightly (Table II). The width of the transect is a function of the detectability of the particular species in question, and so varies slightly with species. Maximum width was about 300 feet.

Each of the six transects was walked three times by Kolb. The transects were also walked twice each by Eugene A. Cardiff, Curator of birds and mammals at the San Bernardino County Museum. Species, lateral distance from the transect to first sighting of bird, and vegetation type were recorded for each bird that could be identified.

The observer walked slowly with frequent short pauses, taking about one hour per transect. Birds which could not be identified were not counted. An attempt was made to avoid counting an identified bird more than once. Following Emlen's guide, squeaking and pishing sounds were used to lure hidden birds into view. The transects were walked at three times beginning (a) from sunrise to 8:30 am PDT (b) in midmorning, finishing by noon; and (c) in the evening beginning at 5:00 pm and finishing by 8:00 pm. A brief summary of dates and weather follows (Table III).

All means of natural detection, visual and auditory, were used and the type of detection recorded with each observation. The location of unseen singing birds was approximated as well as possible after careful scanning.

Since our bird transect sampled essentially a single point in time, the results are not representative of the areas at all times of the year. The best way to remedy this situation is, of course, to sample on a regular basis throughout the course of the year. Since such extensive sampling was not feasible for this phase of the study, literature which might prove helpful in piecing together the annual picture was sought. In addition to published accounts, interviews and suggestions were solicited from knowledgeable people in the area.

Results and Discussion

Good estimates of absolute population density as distinct from indices of relative abundance have been virtually unavailable for nonflocking land birds except in the breeding season when singing males, representing mated pairs, restrict themselves to more or less fixed territories where they or their nests can be counted (Emlin 1971). Since this phase of the study was conducted at a time during the year which found very few, if any, birds nesting, conventional methods involving nest counts, mated pairs, etc. were impossible. There was not sufficient time to use mark and recapture techniques.

While the data was gathered in accordance with the requirements of this method, the data will not be strictly analyzed in terms of determining coefficients of detectability because of the small numbers of individuals recorded for many species. The data so collected also lends itself to determination of relative abundance indices for the various species. While relative abundances will be indicated, the accumulated data which will eventually permit the determination of coefficients of detectability are on file for future reference.

These field observations and a literature review yielded information which allows the creation of a tentative checklist of the 86 birds which may be expected to be found in the coniferous forests of the San Bernardino Mountains in which our six study plots were located (Table V).

The results of 30 bird censuses are summarized in Table VI. In all, some 57 species were observed. Of these 57, 8 species were observed on all 6 study plots; 2 species were observed on 5 of the 6 study plots; 10 species were observed on 4 study plots; 8 species were observed on 3 of the study plots; another 12 species were observed on only 2 of the study plots; and 18 species were only observed on a single study plot. The study plots were paired so that there would be two similar plots in each of three intensities of oxidant air pollution heavy, moderate, and light. The number of species common between the members of each pair is important. This figure may be taken as a crude measure of the similarity of the two plots. Theoretically, the more similar the plots, the greater the number of shared species. The Rim Forest plot and the Camp Angelus plots, representing heavy smog levels, had 19 species (49%) in common out of a total of 39 species found in either or both plots. The Snow Valley plot and the Barton Flats plot representing moderate smog levels had 17 species (45%) in common out of 38 total species. The Sand Canyon plot and the Heart Bar plot representing areas of light oxidant air pollution, were found to have 15 species in common out of 34 total species. There were no significant differences in the number of species observed between plots of the same intensity of oxidant air pollution exposure ($\chi^2 < 2.4$).

Task C for the avifauna of the coniferous forest study plots has primarily been directed at inventory, with the purpose of providing baseline data for future studies as well as revealing the possible presence of gross differences between the study plots.

The effects of oxidant air pollution may either be primary (direct) or secondary (indirect). Primary effects result from exposure of both vegetation and vertebrates to ambient air. Secondary effects result from exposure of both vegetation and vertebrates to ambient air involving a breakdown in the food chain of a species. The determination of primary effects of oxidant air pollution were beyond the scope of this phase but must be considered for any future studies. Increases in eye irritation and/or infection which could decrease visual acuity could have serious effects on flycatchers, hawks and other groups which rely heavily on excellent vision to obtain food. Alterations in metabolic functions and changes in metabolic rates also might occur.

It has been long recognized that a change in one species or a group of species can exert a change in another group or species. In talking about secondary effects we are dealing with the interactions between the various members, both plants and animal, that form the coniferous forest communities we are studying. The myriad of interactions is not well understood, but enough is known to make reasonable predictions and assumptions about what changes have or may occur as a result of oxidant air pollution. Feriancoua-Masaroua and Kalivodoua (1965) studied bird population composition for three years in areas affected by flourine concentrations in the air. The authors found severe damage to conifers and various deciduous species caused a change in the areas which affected the nesting habits of local birds. The number of nesting species was found to be lowest in the zone with maximal damage. Also, a shift of nesting species away from the source of pollution was in progress. It is interesting to note that the number of transient bird species did not appear to correlate with damage. If one considers the breeding season as particularly stressful, it can be hypothesized that the added stress of a disturbed environment was sufficiently great to prohibit successful breeding in the affected areas. Similar changes may be occurring on the San Bernardino National Forest.

Data on hand show that at least 8 species of birds were found on all plots. These eight species could serve as key species to be used in studies designed to show the effects of different levels of oxidant air pollution on birds. The eight species are: mountain chickadee , violet-green swallow, western wood pewee, Steller's jay, Oregon junco, band-tailed pigeon, western blue bird, and the white-breasted nuthatch. Three of these eight species have diets almost strictly limited to insects: the western wood pewee, the violet green swallow, and the western blue-bird. The Steller's jay is more omnivorous, insects comprise from 10 to 45 percent of the diet, acorns to 50 percent, and various other items including elderberry composing the remainder. The diet of the Oregon junco typically is seeds weevils, ants, and other insects. The mountain chickadee and the white-breasted nuthatch feed on both insects and tree seeds. The band-tailed pigeon, on the other hand, subsists largely on acorns, hollyleaf cherry, dogwood, and other fruits. There are advantages in studying both specialized and generalized feeders. The specialized feeder would be particularly sensitive to changes in food supply, and changes in the population characteristics of specialized feeders could reflect changes in the food supply (e.g., pine nuts). On the other hand, generalist feeders may be viewed as ecosystem integrators, tieing strands of the food web together. Changes in population numbers of generalist feeders may, therefore, reflect rather large scale aberrations in ecosystem functioning. The ideal situation, then, is to monitor several species simultaneously.

SMALL MAMMALS

The purpose of this phase of the study was to determine the common small mammal species present on the six study areas. Accompanying the inventory were procedures designed to estimate the relative densities of these populations, and to look for gross indications of disease or abnormalities that might be related to oxidant air pollution.

The field and lab work was accompanied by a brief literature search.

Permanent markers were established for future studies of the small mammal populations.

Procedures

Most of the small mammal data were collected via the use of museum special snap traps set out in standard "Calhoun Line" procedure (Calhoun 1959). Calhoun Type B lines were employed, consisting of 20 trapping stations, each station 50 feet from the rest in a straight line. Three museum special traps used at each station.

Two Calhoun lines were established on each of the six study plots. The lines were laid out approximately parallel to each other and about 50 feet on each side from the centerline established for the plant pathology work. Traps, baited with peanut butter, were placed within 3 feet of a stake.

Following standard procedures the traps were checked for captures morning and evening for a total of three days. Morning runs were begun by 7:00 am and finished before noon, while afternoon runs were begun no earlier than 4:00 pm and were finished by 8:30 pm. The dates the trapping occurred and the numbering system employed are given in Table VII. Table VII also shows the method of naming lines and the locations of the numbered lines. Animals were removed and placed in plastic bags along with labels denoting date and location of capture as well as time of day. The specimens were promptly frozen in the field using dry ice and were later transported to the University of California's Field Station at Sagehen Creek for dissection.

In the lab, specimens were weighed to the tenth gram and standard measurements (total length, tail length, hind foot length, and ear length) were taken. The external anatomy of the specimen was surveyed while looking for ecto-parasites. Ecto-parasites were saved and any unusual coloration or marking was noted. During dissection the body cavity was scrutinized for endoparasites and/or any gross irregularities. Liver and kidneys were examined for cysts, scar tissue, or any other peculiarities. The amount and location of fat deposits were noted. The lungs were cursorily examined for abnormalities. The reproductive tracts, stomachs, and lower jaws were dissected out and retained. All of the items retained were fixed in 10 percent formalin and preserved in 70 percent ethanol for possible future investigation. The carcasses were re-frozen and are being retained for possible future histological work.

The weather on the various trapping dates is given below:

7/19 cool and breezy am, warming pm

7/20 cool, clear, slight breeze (some fog at Rim Forest), warming pm

7/21 warm, clear, slight breeze

7/22 warm, clear

7/26 warm am, cooling with some breeze pm.

7/27 warm, clear am, breeze pm.

7/28 clear, hot am., sultry, smoggy, warm pm with some clouds.

Results and Discussion

Small mammal censusing via Calhoun lines offers several advantages over large mammal studies. Small mammal censuses are less time consuming, less expensive, and can be performed with fewer people. Since smaller animals typically require a smaller area for sustenance, a given area will normally support more small mammals than large mammals. Small mammal study, then usually allows much larger sample sizes for a given amount of field work. Another important factor to consider in working with small mammal populations is the normally short life span of small mammals. Many species of small mammals live less than three years on the average. A short life span has both advantages and disadvantages when studying the effects of oxidant air pollution on an animal population. A short life span means a high turnover rate within the populations. If oxidant air pollution changes the reproductive capacity (or the viability) one, for example, would expect to see changes in population structure. These changes would be more rapidly revealed in a population with a high turnover rate. So, one might expect to see changes in population structure, no matter what the immediate cause, more rapidly in a species population with a short life span and a high turnover rate than in a more long-lived population with a slower turnover rate. A possible disadvantage to working with a population with a high turnover rate might come from the fact a given individual is not exposed to oxident air pollution for a very long period and therefore, may not show primary effects of air pollution.

A cursory review of the literature provided a list of the small mammal species that would likely be found on the six mixed conifer plots studied (Table VIII).

The results of the Calhoun line trapping are seen in Tables IX and X, which summarize all data from the 12 Calhoun lines (two lines per plot). In all, 83 specimens were obtained representing 10 species.

Table X also gives the sex ratios for each species. For species with a sample size larger than five, X^2 tests were performed to determine if deviations from an expected sex ratio of 100 males/100 females were significant. The results follow:

Species	Significant difference?	Confidence level	X^2	d.f.
Peromyscus maniculatus	yes	95%	25	1
Microtus californicus	yes	95%	52	1
Eutamias merriami	no	-	2.56	1
Peromyscus boylii	no	-	.64	1
Neotoma fuscipes	no	-	.20	1

Significant differences, then, occurred only in *Peromyscus maniculatus* and in *Microtus californicus*.

Uneven sex ratios are not uncommon. They are a result of differential mortality (ie. one sex is more vulnerable to some than the other). It is possible that one sex is more strongly affected by oxidant air pollution. Studies designed to further elucidate the differences in the sex ratio as well as to compare these ratios to ratios from areas not affected by oxidant air pollution and to find possible causes for the observed differences should be considered for the future.

The number of individuals caught on each trap line and also on each of the six plots is given in Table IX. For statistical comparison the numbers per plot were compared. The two lines of a given plot were only 100 feet apart, but the plots were separated by a substantial number of miles. There was no significant difference between the number of individuals caught on plots A and F, the heavy oxidant air pollution damage plots (X^2 = 1.8, 1 d.f.). The two plots chosen to represent light oxidant air pollution damage (C & D) also showed no significant difference in total catch between them. The number of species trapped on the two moderate oxidant air pollution plots was, on the other hand, significantly different (X^2 = 17.8, 1 d.f.). In other words, while the two light plots were similar to each other and the two heavy plots were similar to each other, the two moderate plots were not similar as far as the number of individuals trapped is concerned. Armed with this information a few more simple statistical tests can be made.

Since there is no statistical difference between A and F and between C and D, the average of A and F and of C and D are used in the following tests. Using said averages it was found that there were significantly fewer individuals captured on the plots with high oxidant air pollution levels. Presumably there were more animals available to be caught on the light oxidant level plots than on the heavy plots. These differences may be related to air pollution levels, through direct effects on the animals, or indirectly through effects on the vegetation. There is a variety of other possible causes, unrelated to air pollution levels. The reasons for these differences in small mammal population numbers is a high priority study topic.

Since there was a significant difference in the number of individual animals trapped on the two moderate oxidant air pollution plots, it was not valid to combine the two numbers and treat that number as representative of the number of animals on the moderate plot. In view of the difference, B and E were separately tested against the average obtained for the light plots and then against the average obtained for the heavy oxidant air pollution plots. The X^2 tests performed indicated that the number of individuals captured on plot B (Snow Valley) was significantly greater than the average number of individuals trapped on the heavy oxidant air pollution plots ($X^2 = 25.2$, 1 d.f.). There was no significant difference between the number of specimens captured on plot E (Barton Flats) and the average number of individuals trapped on the heavy oxidant air pollution plots ($X^2 = 1.38$, 1 d.f.). The results were slightly different when one considers the light oxidant air pollution plots. The number of individuals trapped on plot B (Snow Valley) was significantly greater, but only at the 90 percent level than the average number of individuals caught on the light plots ($X^2 = 2.76$, 1 d.f.). It was also found, that the number of species caught on plot E (Barton Flats) was significantly (95% level) less than the average number of individuals caught on the light plots ($X^2 = 7.54$, 1 d.f.).

Snow Valley plot and Barton Flats plot are both meant to represent similar areas of moderate oxidant air pollution damage yet on one we see significantly more individuals captured than on the light oxidant air pollution plot, and on the other significantly fewer individuals trapped than on those same light oxidant air pollution damage areas. Probably the sample sizes are too small to make meaningful statements about differences and/or similarities between plots. This criticism is easily remedied by continued sampling of the study areas in question.

The number of species caught per plot was low, ranging from 1 - 6, (Table IX) but showed an interesting trend. The smallest number of species was observed on the plots with the heaviest oxidant air pollution damage while the largest number of species was observed on the plots least affected by oxidant air pollution. At this stage one cannot be certain as to the reasons for these apparent differences but there is the possibility that oxidant air pollution resulting in primary and secondary damage are contributing factors.

While we were not equipped, with either material or time, to do a thorough investigation of the possible primary effects of oxidant air pollution on individual animals, we did look for any apparent anomalies including growths, ecto and endo-parasites, and obvious gross deformities which were observed during the course of the dissections performed on each individual captured. No important anomalies or diseases were evident.

While there has been little work done using wild populations of small mammals as test animals, some work has been performed on laboratory animals which might point the way for future studies and might help histopathologist focus on certain susceptible organs. Gardner et al (1969) suggested that the ambient Los Angeles atmosphere may promote the development of chronic nephritis, a renal degenerative disease, in laboratory rats.

Gardner et al (1970) also reported findings that suggest that prolonged exposure to ambient Los Angeles air is associated, at least in several strains of laboratory mice, with an increased susceptibility to pulmonary infection but not necessarily to increased pulmonary neoplasia. Purvis et al. (1969) found that exposure of mice to ozone reduced their resistance to infection and effectively increased mortality in previously infected mice. Mudd et al. (1969) found that ozone oxidized several amino acids and may contribute to changes in the permeability of the cellular membrane. While it is always dangerous to extrapolate across species lines from findings such as those above, the above experiments may help to suggest possible future experiments. The use of controlled environment chambers can be considered. Combining both plants and animals in the same chambers may be both feasible and economical. Autopsy of animals subjected to filtered and ambient air in controlled environment chambers should be coupled with autopsy findings from animals periodically trapped in the wild to yield the most useful data.

While differences in the small mammal populations on the six study areas appear to be significant, the mechanisms responsible for these differences and the absolute magnitude of these differences needs much further investigation. Hopefully considerable input on other aspects of the forest system will become available as a result of the other aspects of this multidisciplinary study. Data on the characteristics and changes in the vegetation, invertebrate populations, microclimate, and other aspects of the forest ecosystem should go a long way toward delineating the mechanisms of change responsible for the observed differences.

LARGER MAMMALS

The purpose of this portion of the study was to determine the species of larger mammals which were present, or would likely be present, on the six study plots. In this context, "larger mammal" refers to deer, coyotes, etc. but also includes the two tree squirrels found in the area. Evaluation of the present status of these species, relative abundance in the mixed conifer type and the suitability of these species, as indicators of changes in the forest ecosystem due to oxidant air pollution were also considered as goals of this section.

Procedures

Time did not permit much observation of the larger mammals. Records were kept as the opportunity arose during the course of other activities. Larger mammal censusing poses special logistic problems because of the typically extensive range of larger mammals and the correspondingly low population density. Exceptions to the statement regarding low density may be the relatively abundant western gray squirrel and the northern flying squirrel. This section, then, is largely based on literature review coupled with a small number of actual field observations.

Results and Discussion

The number of individuals and the number of larger mammal species in the area is relatively low. Table XI is a list of the principal mammals found in the area which were too large to be captured in the snap traps used for small mammal censusing.

While much is known about some of these species in other areas, scant work has been performed on these species as they occur in the mixed conifer type of the San Bernardino mountains.

Black bear

In 1933 black bear, captured in Yosemite, were released in the San Bernardino National Forest by the California Department of Fish and Game. Six black bears were released near Big Bear Lake, and ten were released in the Santa Ana Canyon region. Since 1933, the bear has wandered extensively, while settling in the general areas of release, and now ranges throughout much of the San Bernardino National Forest. The black bear population in the area has increased and prior to 1970, from 3 to 8 bear were harvested from the Forest annually (Light and Graham 1968).

Areas frequented bythe black bear encompass several of the six oxidant air pollution study areas including: Rim Forest, Heart Bar, and Barton Flats plots. Numbers of bears on these areas, and indeed, on the whole forest, are not high. Light (personal communication dated July 7, 1972) notes that about 15 bears were recorded for the Barton Flats area while the Rim Forest area recorded approximately 5 - 10 bears. The rather localized distribution of bears coupled with their low population numbers would make them poor candidates for an oxidant air pollution damage indicator species.

Long-tailed weasel

Little work has been done on the long-tailed weasel. This species is common in the mixed coniferous ecosystems of the San Bernardino National Forest. The long-tailed weasel is not frequently seen though they are often active by day. The normal home range is from 30 to 40 acres (Burt & Grossenheider 1964) in and adjacent to grass land plant communities, a sizeable area for a mammal a foot long. Populations may reach 15 to 20 per square mile.

Badger

Badgers are relatively rare in the coniferous regions of the San Bernardino mountains. Mostly nocturnal, the badger is often abroad during the day, especially in the early mornings and late afternoons (Burt and Grossenheider 1964; Ingles 1965). On a national scale, badgers are rapidly decreasing in number because of conflicts with man.

Coyote

Coyotes are present in most of the vegetation types found in the San Bernardino National Forest. While they are most common in open woodlands, they are occasionally seen in the coniferous forest. This summer we observed 4 coyotes; one on the dirt road leading to the Sand Canyon plot and another one-half mile west of the Snow Valley plot, and two were seen in the vicinity of the Heart Bar plot.

Coyotes utilize large areas for food gathering, a normal hunting route being up to 10 miles long. The coyote is a highly adaptive animal, with a diet ranging from manzanita berries to rodents or larger susceptible mammals. The fact that coyotes frequently utilize many different vegetation types limits their usefulness as indicators of change over a wider variety of vegetation types must not be overlooked. The high adaptability of the coyote may also limit its use as an indicator since coyotes have been able to maintain their numbers elsewhere in spite of rather drastic changes in their native habitat.

Bobcat

The bobcat is a rare inhabitant of the coniferous forest ecosystem of the San Bernardino National Forest. While the bobcat may wander 25 to 50 miles, it usually frequents an area with a radius of about 2 miles. Bobcats are usually nocturnal and solitary. When analyzing the bobcat's suitability as an indicator species, the same caveats (biotic laws) regarding range size must be considered for the bobcat as for the coyote mentioned above.

Mountain lion

The rarely seen mountain lion ranges throughout the San Bernardino National Forest. Chiefly nocturnal, lions may be abroad during the day. Except when the cubs are small, the mountain lion roams widely and may move 75 to 100 miles from its place of birth. The large range, the small numbers and the difficulty of observation make the mountain lion a rather poor candidate for an animal to monitor changes in the forest ecosystem. The number and/or frequency of occurrence of lions on the six study plots is not known by the authors although a mountain lion was reportedly seen near the plot at Heart Bar in early July, 1972.

Western gray squirrel

The western gray squirrel is abundant throughout the mixed coniferous forest areas of the San Bernardino mountains. This species is arboreal but is often seen on the ground. The home range is typically from one-half to two acres. Populations vary from 2 squirrels per acre to 1 squirrel for ten acres. Western gray squirrels feed mostly on acorns and conifer seeds.

Western gray squirrels were abundant on all of the six study plots, although no measurements were made of population densities. Because of its rather heavy dependence upon food from the principal trees, sometimes resulting in tree depredation, of the mixed conifer type, the western gray squirrel would be a good candidate for more intensive study. The size of the home range, the relative abundance of this species and the ease of observation, are also favorable factors that would facilitate future studies. Gray squirrels have received attention in other areas because of their classification as a game animal.

Northern flying squirrel

Little is known about the nocturnal northern flying squirrel. The estimated home range is about 4 acres. Population levels of 1 to 2 per acre in the summer are not uncommon in other areas. While no northern flying squirrels were observed, probably due to their nocturnal habits, there have been sight records from Camp Angelus. The numbers and presence of northern flying squirrels on the six plots today are unknown. The northern flying squirrel, like the western gray squirrel, does not hibernate and so is active and available for study, weather permitting, year around. The northern flying squirrel is somewhat more omnivorous than the western gray squirrel.

Mule deer

As the most important big game animal of the Pacific States, the mule deer has received considerable attention and study. Mule deer usually occur singly or in small groups, although they are considerably more gregarious in winter. The home range typically includes from 90 to 600 acres or more.

Longhurst et al. (1952) note that the carrying capacities of most southern California deer ranges are low, largely due to the relatively low density of desirable forage plants. The authors also note that most of the deer in the region do not exhibit migratory habits but on occasion there may be elevational drift primarily due to inclimate weather conditions, a factor that should be appreciated when considering this species for future study.

A considerable amount of time and effort has been devoted to surveying the deer herds of the San Bernardino Mountains by both the United States

Forest Service and the California Department of Fish and Game. Some of these studies covered the area incorporated by one or more of the six oxidant air pollution damage plots. Anyone contemplating future work on the deer found on these plots is referred to Light (1965) and the 2620 Deer Herd Inspection files for Bacon Flats and Converse located at the Arrowhead District Ranger Office at Rim Forest and the San Gorgonio District Ranger Office at Mill Creek, respectively. The inspection areas at Bacon Flats and Converse are within the study plots.

The only deer we observed on the plots was a single doe at Heart Bar. The low population numbers and large ranges pose difficulties in studying this species. The fact that deer tend to follow definite trails aids in observation. Their primary forage plants in the area of the study plots are *Ceanothus cordulatus*, *Cercocarpus ledifolius*, and acorns of *Quercus* species. The mule deer is a questionable target species for detailed study as an indicator of changes due to oxidant air pollution.

Not much is known about larger mammal populations, on the study areas. Most of these animals are only rarely found in the mixed conifer ecosystem of the San Bernardino mountains. From ease of study and suitability, the western gray squirrel seems to be the candiate from this group for further study.

REPTILES AND AMPHIBIANS

The purpose of this portion of the study was to determine the species of reptiles and amphibians which were present, or would likely be present, on the six study plots. Evaluation of the present status of these species, and their relative abundance, were also goals.

Procedures

Time did not permit much observation of reptiles and amphibians. We did make one transect on each study plot to count the number of lizards observed in a given distance. Mary Kay Kolb walked a total of two thousand feet on each plot by traversing the two Calhoun lines we had previously staked. Lizards could be observed for a distance of aboutten feet on either side of the line walked. Each lizard seen was recorded and the number of the Calhoun line stake nearest the siting was recorded. Species identification was not always possible, but most were sagebrush lizards. The dates of observation, times and weather are seen in Table XII. The numbers obtained from the walks are a rough index of the suitability of the study plots for lizard habitat. The field work was accompanied by a cursory literature search.

Results and Discussion

The coniferous forest zone of the San Bernardino mountains supports several reptile and amphibian species. A preliminary list of the species, including relative abundance when known, is found in Table XIII.

Time did not permit detailed study of any of the above species. No literature was discovered pertaining to the affects of oxidant air pollution on reptiles and/or amphibians. None of the reptiles and amphibians listed above are primary consumers. Changes in the organisms they require for food would be expected to cause changes in the relative abundance of the herpetofauna. Primary affects of oxidant air pollution on reptiles and amphibians are unknown.

The Calhoun line trapping mentioned above netted 11 Sagebrush lizards and 2 Southern alligator lizards. One Sagebrush lizard was captured on line A (Rim Forest), B (Snow Valley) and C (Sand Canyon) and 8 Sagebrush lizards were captured on line F (Camp Angelus). One Southern alligator lizard was captured on line F (Camp Angelus) and one was captured on line

E (Barton Flats). Sagebrush lizards were abundant on the Camp Angelus study plot which was representative of heavy oxidant air pollution damage.

Chi square tests were performed to see if any of the differences noted were significant. The number of lizards observed at Camp Angelus was found to be significantly greater than the number observed on any other plot (X^2 = 14.8 to 38, 1 d.f.). The number observed at Snow Valley was significantly higher than the numbers observed at Sand Canyon (X^2 = 4.6, 1 d.f.) and at Heart Bar (X^2 = 11, 1 d.f.). The number observed at Barton Flats was significantly greater than the number observed at Heart Bar (X^2 = 7, 1 d.f.). All other differences appear to be nonsignificant.

The precise reasons for the much greater number of lizards at Camp Angelus are unknown. These lizards are relatively plentiful and might well serve as indicators of forest ecosystem change due to oxidant air pollution. Both the causes for the differences in numbers and the suitability of these species as indicators await further study.

Future studies should be directed at determining precisely which amphibian and reptile species are present on the study plots; the relative numbers of these species; the affects of various levels and durations of oxidant air pollution on these species (both primary and secondary affects); and, the suitability of these species as indicators of forest ecosystem change, especially change due to changing levels of oxidant air pollution. The Sagebrush lizard probably would be the best choice for detailed study.

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Proposed Investigation

Preliminary research proposal

Impact of oxidant air pollutants on terrestrial vertebrates in the mixed conifer forest.

Principal Investigator: Marshall White.

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Filed concurrently with this proposal is a summary of the terrestrial vertebrate survey (Task C). One of the major purposes of Task C was to establish the course of future studies. While the Task C studies were cursory, we do have at hand an impression of the character of the terrestrial vertebrate fauna, and a list of key species that merits study in depth.

Objectives

Studies with the following objectives are in order.

1) Describe in detail the terrestrial vertebrate fauna
2) Describe in detail the ecology, population dynamics and food habits of a few key species, and then relationships and impact on Ponderosa and Jeffrey pine.
3) Describe the direct (physical and physiological) effects of oxidant air pollutants on individuals.
4) Compare the findings from (1-2-3) above with information from similar habitats, including areas with no oxidant air pollution problems.
5) Characterize the effects of various levels of oxidant air pollutants on this fauna, on the individual key populations, and on individuals.
6) Compare the vertebrate fauna of today with that recorded in 1908 by Joseph Grinnell (Grinnell, J. 1908. The biota of the San Bernardino

Mountains. U. C. Publs. in Zoology 5(1):1-170.) This provides an unique opportunity to assess changes to a forest covered by man over a 60-year period.

Term of Study: 3 to 5 years

Procedures

A study of 3 - 5 year duration is proposed. The studies would proceed along these basic lines of endeavor.

1) CHARACTERIZATION OF THE TERRESTRIAL VERTEBRATE FAUNA

The goal is to have a thorough understanding of the nature of the group of terrestrial vertebrates utilizing the various habitats and different levels of oxidant air pollution within the mixed conifer area and their relationship to and impact upon Ponderosa and Jeffrey pine. This includes analysis of occurrence, distribution; abundance, seasonal and annual variation, habitat affinities, interrelationships. Comparisons with control areas.

2) DETAILED ANALYSIS OF THE ECOLOGY AND POPULATION DYNAMICS OF KEY, INDICATOR SPECIES.

The goal is to gather detailed population data on a few species that are important in the whole system, using these populations as indicators and measurers of the effects of oxidant air pollution on terrestrial vertebrates in the mixed conifer system. Reproductive performances and food habits measures and comparisons will be emphasized.

Topics to be included:

Population density, sex ratios. age ratios, productivity, survival, food habits, habitat requirements, effects of habitat alterations, animal interrelationships, plant-animal interrelationships.

Species to be included:

Species tentatively selected for detailed study are as follows:

Birds

mountain chickadee
Steller jay
Cassin finch
white-breasted nuthatch
Oregon junco

Mammals

brush mouse
deer mouse
Merriam chipmunk
western gray squirrel

3) CHARACTERIZATION OF THE DIRECT (PHYSICAL AND PHYSIOLOGICAL) EFFECTS OF OXIDANT AIR POLLUTANT ON TERRESTRIAL VERTEBRATES

The goal is to compare the health and vigor of individuals exposed to various levels of oxidant air pollutants with that of individuals from control areas.

to include comparisons of:

size and weight, condition, growth rates, external tissue pathology, internal tissue pathology, disease and parasite loads.

Techniques

A variety of techniques will be used, such as field counts and observations, livetrapping, kill-trapping, mist netting, collecting by shooting, to obtain information in the field. Laboratory procedures would include standard preparation, preservation, and necropsy procedures, and experimentation with individuals in environmental chambers containing various levels of oxidant air pollutants if facilities and resources are available.

Table I. Estimated tree and shrub crown cover on the study plots.

Plot	Percentage cover
Rim Forest (Dogwood)	64
Snow Valley	52
Sand Canyon	55
Heart Bar	47
Barton Flats (Boy Scout Camp)	42
Camp Angelus	49

Table II. Estimated abundance of the common woody plant species on the study plots.

Species	Plot	Per cent of total per study plot					
		Rim Forest	Snow Valley	Sand Canyon	Heart Bar	Barton Flats	Camp Angelus
Jeffrey pine			38	41	43	25	
Ponderosa pine		46				60	55
White fir		23	5	22	8		13
Black oak		18	15			15	16
Sugar pine		11	15				Tr.
Incense cedar		1					
Juniperus sp				5			
Mt. Mahogany				22	15		
Ceanothus sp			25	2	14		
Salix sp			Tr.	6	Tr.		
Arctostaphylos sp			1	1	15		
Rabbit brush			1	1	5		
Ribes sp		1					
Chaparral flowering ash							15

Table III. Bird census dates and weather conditions.

Plot	Date	Early am	Date	Mid-am	Date	Pm
Rim Forest	8/1	clear,warm	8/2	clear,warming slight breeze	8/1	clear,heavy smog,moderate breeze
Snow Valley	8/2	cool,clear, calm	8/1	clear,warm	8/2	clear,cooling slight breeze
Sand Canyon	8/5	cool,clear, calm	8/5	moderately warm,windy, scattered clouds	8/2	cooling,clear some smog
Heart Bar	8/5	warm, clear, slight breeze	8/2	clear,warm	8/2	smoggy but clear, slight breeze, warm but cooling.
Barton Flats	8/3	very cool, clear	8/4	warming,clear	8/4	warm, smoggy
Camp Angelus	8/3	cool,clear, slight breeze	8/4	warm,clear slight breeze	8/4	windy,warm very smoggy

Table IV. Bird census dates and times from Eugene Cardiff.

Date	Plot	Time	Weather
8/8/72	Snow Valley	8:22 am	clear, calm, cool
8/8/72	Sand Canyon	10:55 am	cool, partly cloudy thunder and lightening
8/8/72	Heart Bar	4:15 pm	cool, partly cloudy, just after rain showers
8/10/72	Camp Angelus	8:30 am	clear, calm, cool
8/10/72	Barton Flats	10:07 am	clear, calm, warm
8/10/72	Rim Forest	4:08 pm	cool, partly cloudy, just after rain showers
8/23/72	Snow Valley	7:06 am	not recorded
8/23/72	Sand Canyon	9:54 am	"
8/23/72	Rim Forest	3:50 pm	"
8/24/72	Camp Angelus	8:07 am	"
8/24/72	Barton Flats	9:30 am	"
8/24/72	Heart Bar	11:10 am	"

Table V. Tentative checklist of the common birds of the coniferous forests of the San Bernardino Mountains.[*] Listed in Phylogenetic Order

Species	Status	Principal foods
FALCONIFORMES		
Accipitridae		
Goshawk (*Accipiter gentilis*)	rare winter visitor	upland mammals and birds
Sharp-shinned hawk (*Accipiter striatus*)	winter visitor rarely resident	small upland birds, large insects
Cooper's hawk (*Accipiter cooperii*)	resident	upland birds and mammals
Red-tailed hawk (*Buteo jamaicensis*)	resident	small upland mammals
GALLIFORMES		
Phasianidae		
Mountain quail (*Oreortyx pictus*)	resident	insects (10%) seeds, lupine, clover, etc.
COLUMBIFORMES		
Columbidae		
Mourning dove (*Zenaidura macroura*)	resident	seeds, turkey mullein, fiddleneck
Band-tailed pigeon (*Columba fasciata*)	resident	acorns, hollyleaf cherry, dogwood, other fruits and seeds
STRIGIFORMES		
Strigidae		
Great horned owl (*Bubo virginianus*)	resident	medium sized mammals and birds
Pygmy owl (*Glaucidium gnoma*)	resident	insects, small mammals
Flammulated owl (*Otus flammeolus*)	summer resident	small rodents

Table V (Cont'd)

Species	Status	Principal foods
Purple martin (*Progne subis*)	summer resident	winged insects
Corvidae		
Steller's Jay (*Cyanocitta stelleri*)	resident	insects (10-45%) acorns (50%) elderberry
Clark's nutcracker (*Nucifraga columbiana*)	resident	grasshoppers, pine nuts (up to 75%)
Paridae		
Mountain chickadee (*Parus gambeli*)	resident	insects, conifer seeds
Sittidae		
White-breasted nuthatch (*Sitta carolinensis*)	resident	beetles, acorns, pine nuts
Red-breasted nuthatch (*Sitta canadensis*)	resident	beetles, pine nuts
Pygmy nuthatch (*Sitta pygmaea*)	resident	spittlebugs, ants pine nuts
Certhiidae		
Brown creeper (*Certhia familiaris*)	resident	spiders, bark beetles, etc., pine nuts
Troglodytidae		
Bewick wren (*Thryomanes bewickii*)	resident	insects, limited amt. of seeds
House wren (*Troglodytes aedon*)	resident	insects, limited amot. of seeds.
Turdidae		
Hermit thrush (*Hylocichla guttata*)	summer resident	beetles, ants, etc.
Western bluebird (*Sialia mexicana*)	resident	grasshoppers, beetles, etc. (75-100%)

Table V (Cont'd)

Species	Status	Principal foods
Screech owl (*Otus asio*)	resident	small rodents, insects
Saw-whet owl (*Aegolius acadicus*)	resident	insects, small mammals
Spotted owl (*Strix occidentalis*)	resident	small rodents
Long-eared owl (*Asio otus*)	resident	reptiles and small rodents
CAPRIMULGIFORMES		
Caprimulgidae		
Common nighthawk (*Chordeiles minor*)	summer resident	insects
APODIFORMES		
Apodidae		
White-throated swift (*Aeronautes saxatalis*)	resident	insects
Trochilidae		
Anna's hummingbird (*Calypte anna*)	resident	penstemon, tree tobacco, manzanita,et
Calliope hummingbird (*Stellula calliope*)	summer resident	penstemon, tree tobacco manzanita
Rufus hummingbird (*Selasphorus rufus*)	summer migrant	penstemon, tree tobacco
Allen's hummingbird (*Selasphorus sasin*)	summer migrant	penstemon, tree tobacco manzanita
PICIFORMES		
Picidae		
Red-shafted flicker (*Colaptes cafer*)	resident	ants, other insects (45-100%), acorns
Yellow-bellied sapsucker (*Sphyrapicus varius*)	resident	beetles, ants, insects (30-85%) tree sap, some fruit

Table V (Cont'd)

Species	Status	Principal foods
Williamson's sapsucker (*Sphyrapicus thyroideus*)	resident	insects, cambium and inner bark, mostly pine
Acorn woodpecker (*Melanerpes formicivorus*)	resident	acorns, (40-90%), insects
Hairy woodpecker (*Dendrocopos villosus*)	resident	barkbeetle larvae, ants, caterpillars, adult beetles, etc. (75-80%), dogwood
White-headed woodpecker (*Dendrocopos albolarvatus*)	resident	ants, pinyon nuts (70%), insects
Lewis woodpecker (*Asyndesmus lewis*)	winter visitor	ants, other insects (no grubs) 30-60%) acorns, elderberry
PASSERIFORMES		
Tyrannidae		
Ash-throated flycatcher (*Myiarchus cinerascens*)	summer resident	winged insects
Hammond flycatcher (*Empidonax hammondii*)	migrant	winged insects
Dusky flycatcher (*Empidonax oberholseri*)	summer resident	winged insects
Western flycatcher (*Empidonax difficilis*)	summer resident	winged insects
Olive-sided flycatcher (*Nutallornis borealis*)	summer resident	winged insects
Western kingbird (*Tyrannus verticailis*)	resident? winter visitor	bees, wasps, grasshoppers, etc.
Western wood peewee (*Contopus sordidulus*)	summer resident	winged insects
Traill's flycatcher (*Empidomax traillii*)	summer resident	winged insects
Hirundinidae		
Violet-green swallow (*Tachycineta thalassina*)	summer resident	insects
Tree swallow (*Iridoprocne bicolor*)	summer resident	insects, dogwood

Species	Status	Principal foods
Mountain bluebird (*Sialia currucoides*)	resident	ground beetles, weevils (75-100%)
Towendsend's solitaire (*Myadestes townsendi*)	resident	beetles, juniper berries, pine
Robin (*Turdus migratorius*)	summer visitor winter visitor	caterpillars, earthworms, etc. juniper berries, cherries, etc.
Sylviidae		
Golden-crowned kinglet (*Regulus satrapa*)	resident	wasps, bugs, flies
Vireonidae		
Solitary vireo (*Vireo solitarius*)	summer resident	insects, some berries
Warbling vireo (*Vireo gilvus*)	summer resident	insects (90%)
Parulidae		
Audubon's warbler (*Dendroica auduboni*)	summer resident	ants, bugs, spiders, etc. (0-28%)
Black throated gray warbler (*Dendroica nigrescens*)	summer resident	insects
Myrtle warbler (*Dendroica occidentalis*)	winter visitor	flies, beetles, ants, etc. (80-100%) fruits (up to 20% in winter)
Townsend's warbler (*Dendroica townsendi*)	winter visitor	insects
Wilson's warbler (*Wilsonia pusilla*)	summer resident	insects
Painted redstart (*Setophaga picta*)	rare winter visitor	insects
Black-throated green warbler (*Dendroica virens*)	rare visitor	insects
Nashville warbler (*Vermivora ruficapilla*)	rare visitor	insects

Table V (Cont'd)

Species	Status	Principal foods
Hermit warbler (*Dendroica occidentalis*)	rare visitor	insects
Orange-crowned warbler (*Vermivora celata*)	summer resident	insects
MacGillivray's warbler (*Oporornis tolmiei*)	rare visitor	insects
Thraupidae		
Western tanager (*Piranga ludoviciana*)	summer resident	wasps, bees, ants, beetles, etc.(85-95%)
Fringillidae		
Black-headed grosbeak (*Pheucticus melanocephalus*)	summer resident	insects, spiders, etc. (30-60%), elderberry, fruits
Cassin's finch (*Carpodacus cassinii*)	resident	insects, nuts
House finch (*Carpodacus mexicanus*)	resident	aphids, caterpillars, etc. (0-8%); filaree, turkey mullein, mustard (95-100%)
Purple finch (*Carpodacus purpureus*)	resident winter visitor	insects, nuts
Evening grosbeak (*Hesperiphona vespertina*)	winter visitor	beetles, caterpillars, etc. pine, wild cherry, manzanita, etc. (20-100%)
Pine siskin (*Spinus pinus*)	summer resident	caterpillars,spiders, etc. (10-80%), filaree, pine, alder, etc. (20-90%)
Lawrence's goldfinch (*Spinus lawrencei*)	resident	aphids, caterpillars, (50% spring); sunflower star thistle, filaree, (50-100%)
Lesser goldfinch (*Spinus psaltria*)	resident	aphids, caterpillars (0-10%) starthistle (54%) pigweed, etc. (90-100%)

Table V (Cont'd)

Species	Status	Principal foods
Red crossbill (*Loxiia curvirostra*)	resident	spiders, caterpillars, etc. (2-18%), pine nuts, fir seeds, etc. (82-100%
Rufous-sided towhee (*Pipilo erythrophthalmus*)	resident	beetles, ants, moths, etc. (9-51%); pigweed, elderberry, etc. (40-85%)
Green-tailed towhee (*Chlorura chlorura*)	summer resident	beetles, ants, etc. (15-60%) pigweed, elderberry, etc. (40-85%)
Lazuli bunting (*Passerina amoema*)	summer resident	grasshoppers, etc. wild oats, miner's lettuce, needle grass, etc. (50-60%).
Chipping sparrow (*Spizella passerina*)	summer resident	grasshoppers, other insects (0-66%); filaree, wildoats, etc. (34-100%)
Fox sparrow (*Passerella iliaca*)	winter resident	millipeds, ground beetle (7-48%), ragweed, etc.
White-crowned sparrow (*Zonotrichia leucophrys*)	summer resident	parasitic flies, ants, etc. (0-35%) pigweed, other grasses, etc. (65-100%)
Lincoln's sparrow (*Melospiza lincolnii*)	summer resident	beetles, ants, etc. (7-69%) pigweed, etc., (31-83%)
Oregon junco (*Junco oreganus*)	resident	weevils, ants, seeds
Gray-headed junco (*Junco caniceps*)	rare winter visitor	ants, pine, seeds
Slate-colored junco (*Junco hyemalis*)	rare winter visitor	weevils, other insects, wildoats, chickweed, etc
Pine grosbeak (*Pinicola enucleator*)	uncertain	seeds, fruits

*Largely from Peterson 1961, and Light and Graham 1968 .

Table VI. Relative abundance of the species of birds observed on the 6 study plots. Relative abundance figures 1 - 5 represent actual numbers of birds observed as follows: 1 = 14 sightings, or more; 2 = 9-13; 3 = 5-8; 4 = 2-4; and 5 = 1 sighting.

	Relative abundance on study plots						
Species	Rim	Camp Angelus	Snow Valley	Barton Flats	Sand Canyon	Heart Bar	# of plots on which species observed
Cooper Hawk			5		5		2
Redtail Hawk		5		4	5	4	4
Mt. Quail			4				1
Mourning Dove	5	4					2
Bandtail Pigeon	3	1	3	2	4	5	6
Gt. Horned Owl			5				1
Flamulated Owl				5			1
Spotted Owl	4						1
Common Nighthawk		3				1	1
Whitethroated Swift						1	1
Anna Hummingbird	4	4	3	5			4
Allen Hummingbird	4	5	4				3
Rufous or Allen Hummingbird	5	5	1				3
Redshafted Flicker	3	4	4	4	3		5
Yellowbelly Sapsucker			4	5	4	4	4
Williamson Sapsucker			5		5	4	3
Acorn Woodpecker		3	4	1			3
Hairy Woodpecker	3	3	4			4	4
Whiteheaded Woodpecker	3	3	4			4	1
Ashthroated Flycatcher	4	4	4	5			4
Dusky Flycatcher			4			4	2
Western Flycatcher			5				1
Olivesided Flycatcher			5	5		5	3
Western Kingbird	5					5	2
Trail Flycatcher	5						1
Western Wood Pewee	4	5	3	4	4	2	6
Violet-Green swallow	2	3	1	1	2	1	6
Steller Jay	1	1	1	1	3	4	6
Clark Nutcracker					3		1
Mt. Chickadee	1	1	1	1	1	1	6
Whitebreasted Nuthatch	4	3	3	3	4	5	6
Redbreasted Nuthatch				5		5	2
Pygmy Nuthatch			5	3	2	1	4
Brown Creeper	4	4	4	4			4
Bewick Wren					4	4	2
House Wren	4		4	4		4	4
Western Bluebird	3	2	4	3	3	2	6
Robin	4						1
Solitary Vireo		4				5	2
Warbling Vireo	5			5			2
Audubon Warbler		5		5			2

Table VI continued

	Relative abundance on study plots						
Species	Rim	Camp Angelus	Snow Valley	Barton Flats	Sand Canyon	Heart Bar	# of plots on which species observed
Blackthroated Gray Warbler	5				5	5	3
Wilson Warbler		5	3	5		4	4
Nashville Warbler	5		4				2
Hermit Warbler	5	5					2
Orange Crown Warbler		5	3		4	4	4
Macgillivray warbler						5	1
Western Tanager						4	1
Blackheaded Grosbeak						5	1
Cassin Finch	3	4	3	5		1	5
Lawrence Goldfinch						4	1
Lesser Goldfinch	4						1
Chipping Sparrow	3	3	4				3
Fox Sparrow	5		4			5	3
Oregon Junco	3	2	1	2	4	4	6
Lazuli Bunting	4						1
Rufoussided Towhee	4		5				2

Table VII. Mammal trapping dates and line designations.

Plot	Lines	Dates (inclusive)
Rim Forest	A 1-A 20, and A21 - A40	July 19, 1972 P.M. to July 22, 1972 A.M.
Snow Valley	B1 - B20, and B21 - B40	July 19, 1972 A.M., to July 21, 1972 P.M.
Sand Canyon	C1 - C20, and C21 - C40	July 19, 1972 A.M., to July 21, 1972 P.M.
Heart Bar	D1 - D20, and D21 - D40	July 26, 1972 A.M., to July 28, 1972 P.M.
Barton Flats	E1 - E20, and E21 - E40	
Camp Angelus	F1 - F20 and F21 - F40	

Table VIII. Preliminary list of small mammals occurring in coniferous forest areas of the San Bernardino Mountains.*

Species	Food
INSECTIVORA	
Soricidae	
Ornate shrew (*Sorex ornatus*)	earthworms
CHIROPTERA	
Vespertilionidae	
Yuma myotis (*Myotis yumanensis*)	insects
Long-eared myotis (*Myotis evotis*)	insects
Long-legged myotis (*Myotis volans*)	insects
CARNIVORA	
Mustelidae	
Long-tailed weasel (*Mustela frenata*)	mice
RODENTIA	
Sciuridae	
Golden-mantled ground squirrel (*Spermophilus lateralis*)	seeds, fruits, insects, eggs, meat
Merriam chipmunk (*Eutamias merriami*)	pine nuts, seeds
Lodgepole chipmunk (*Eutamias speciosus*)	pine nuts, seeds
Geomyidae	
Pocket gopher (*Thomomys bottae*)	roots, tubers, bromegrass, fescue
Heteromyidae	
California pocket mouse (*Perognathus californicus*)	Incense cedar seeds, grass and forb seeds
Pacific kangaroo rat (*Dipodomys agilis*)	bromegrass, seeds

Table VIII. Continued

Species	Food
Cricetidae	
Deer mouse (*Peromyscus maniculatus*)	Seeds, pine nuts, acorns, insects
Brush mouse (*Peromyscus boylei*)	Acorns, pine nuts, seeds, berries
Pinyon mouse (*Peromyscus truei*)	seeds, nuts
Dusky-footed woodrat (*Neotoma fuscipes*)	seeds, nuts, acorns, fruits, green vegetation, fungi
California meadow mouse (*Microtus californicus*)	grasses, sedges, other green vegetation

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*Largely from Light and Graham, 1968; Ingles, 1965; and Burt and Grossenheider, 1964.

Table IX. Trapping results of small mammals on the six study plots (2 lines per study plot).

Species	Rim Forest		Snow Valley		Sand Canyon		Heart Bar		Barton Flats		Camp Angelus		Total
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
_P_. _boylei_	1		12	12	1				1	1			28
_E_. _merriami_	2	1		1	3	5	3	4					19
_P_. _maniculatus_					9	1	2	2		1	1		16
_M_. _californicus_			1	4						2			7
_N_. _fuscipes_			1	1	1	2							5
_E_. _speciosus_							1	2					3
_S_. _lateralis_							1	1					2
_P_. _truei_							1						1
_D_. _agilis_								1					1
_S_. _ornatus_										1			1
Total individuals	4		32		22		18		6		1		83
Total species	2		4		4		6		4		1		10

Table X. Catch from 12 Calhoun lines in the mixed conifer forest of the San Bernardino National Forest.

Species	#caught	Percent of total catch	Percent males
Peromyscus boylei	28	34	54
Eutamias merriami	19	23	42
Peromyscus maniculatus	16	19	75*
Microtus californicus	7	9	14*
Neotoma fuscipes	5	5	40
Eutamias speciosus	3	4	100
Spermophilus lateralis	2	3	0
Peromyscus truei	1	1	100
Dipodomys agilis	1	1	0
Sorex ornatus	1	1	0
Totals	83	100	

*Sex ratio significantly different from 1:1 at 95% level

Table XI. Preliminary list of the larger mammals occurring in coniferous areas of the San Bernardino Mountains.*

Species	Principal foods	Relative abundance
Carnivora		
Ursidae		
Black bear (*Euarctos americanus*)	small mammals, berries, nuts, tubers, insects, eggs, carrion, garbage	3
Mustelidae		
Long-tailed weasel (*Mustela frenata*)	small mammals to rabbit size, some birds	2
Badger (*Taxidea taxus*)	small rodents	3
Canidae		
Coyote (*Canis latrans*)	rabbits, small rodents fruits	3
Felidae		
Bobcat (*Lynx rufus*)	small mammals, few birds	3
Mountain lion (Felis concolor)	deer, rabbits, rodents	3
Rodentia		
Sciuridae		
Western gray squirrel (*Sciurus griseus*)	acorns, seeds of conifers	1
Northern flying squirrel (*Glaucomys sabrinus*)	acorns, seeds, nuts insects, bird eggs	2
Artiodactyla		
Cervidae		
Mule deer (*Odocoileus hemionus*)	shrubs, twigs, and herbs	3

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*Largely based on Light and Graham 1968; Burt and Grossenheider 1964; and Ingles 1965.

**Key to relative abundance figures: 1 - abundant; 2 - fairly common; 3 - rare.

Table XII. Observation dates and weather for lizard counts.

Plot	Date	Time	Weather
Rim Forest	8/8/72	8:45 - 9:20 am	moderately warm, clear
Snow Valley	8/8/72	10:30 -10:55 am	warm, clear
Sand Canyon	8/8/72	12:25 - 1:00 pm	cloudy, warm, rain began as count ended.
Heart Bar	8/9/72	8:17 - 8:45 am	clear, cool but warming; damp ground
Barton Flats	8/9/72	12:00 - 1:05 pm	hot, calm, some scattered clouds.
Camp Angelus	8/8/72	2:58 - 3:30 pm	warm, rain before start but clearing.

Table XIII. Preliminary list of the amphibians and reptiles occurring in coniferous areas of the San Bernardino Mountains.*

Species	Principal food	Relative abundance
Lizards		
Sagebrush lizard (*Sceloporus graciosus*)	insects	1**
Side-blotched lizard (*Uta stansburiana*)	insects	1
Granite night lizard (*Xantusia henshawi*)	insects	2
Western skink (*Eumeces skiltonianas*)	insects	2
Gilbert's skink (*Eumeces gilberti*)	insects	2
Southern alligator lizard (*Gerrhonotus multicarinatus*)	insects	-
California legless lizard (*Anniella pulchra*)	insects	2
Snakes		
Rubber boa (*Charina bottae*)	small mammals & lizards	-
Ring-necked snake (*Diadophis punctatus*)	insects	-
Mountain kingsnake (*Lampropeltis zonata*)	small mammals	2
Striped racer (*Masticophis lateralis*)	small mammals	-
Western terrestrial garter snake (*Thamnophis elegans*)	small mammals, fish	-
Western diamond-back rattlesnake (*Crotalus atrox*)	mammals	3

Table XIII. Continued

Species	Principal food	Relative abundance
Amphibians		
Ensatina (*Ensatina eschscholtzi*)	insects	3
California slender salamander (*Batrachoseps attenuatus*)	insects	-
Western toad (*Bufo boreas*)	insects	-
Pacific tree-frog (*Hyla regilla*)	insects	-

*Largely from Stebbins 1966; Light and Graham 1968.

**Relative abundance: 1 = numerous; 2 = moderately abundant; 3 = uncommon.

Section VIII

Insectan Fauna Associated with Trees Along Transects of Oxidant Air Pollution in the San Bernardino Mountains, 1972

David L. Wood and Donald L. Dahlsten

This survey was conducted August 28-30, 1972, by the following scientists:

U. C. Berkeley

Dr. Field W. Cobb, Jr.	Department of Plant Pathology
Dr. Peter A. Rauch	Department of Entomological Sciences
Dr. Richard Garcia	" "
Dr. Donald L. Dahlsten	" "
Dr. David L. Wood	" "
Mr. David J. Voegtlin	" "
Dr. Joe R. McBride	School of Forestry and Conservation

U. C. Riverside

Dr. Robert F. Luck	Department of Entomology

U. S. Forest Service

Dr. Paul R. Miller	Pacific Southwest Forest & Range Experiment Station
Mr. Kenneth M. Swain	Regional Office, R-5

The survey was conducted in the plots established by Swain, Miller, and R. Thibaud, U. S. Forest Service and described in this report by McBride.

Dogwood - Severe Oxidant Injury

Coleoptera: Scolytidae

1. Ponderosa pine - 16" dbh - killed by Dendroctonus brevicomis - tree abandoned.
2. Incense cedar - 9" dbh - occupied by Phloeosinus sp. - evidence of woodpecker predation.

3. Ponderosa pine - 1-5" dbh - killed by *Ips latidens*.

4. Ponderosa pine - 8" dbh - fresh attacks by *Dendroctonus ponderosae* - pitch tubes present.

5. Ponderosa pine - 6" dbh - fresh attacks by *Dendroctonus ponderosae* - pitch tubes present.

6. Ponderosa pine - 10" dbh - killed by *D. brevicomis* - larvae present - severe oxidant injury.

7. Ponderosa pine - *Pityophthorus* in dead tip.

8. Ponderosa pine - 32" dbh - killed by *D. brevicomis* - larvae at base of tree (#97).

9. Ponderosa pine - 24" dbh - *D. brevicomis* and *D. ponderosae* in dead tree.

10. Ponderosa pine - several with *I. latidens*.

11. Ponderosa pine - 4" dbh - *I. latidens* and flatheaded borers.

12. White fir - 24" dbh - killed by *Scolytus ventralis* - larvae present. Also under attack by the ambrosia beetle, *Platypus*.

Hymenoptera: Pamphilidae

Sawfly larvae of *Acantholyda* sp. on ground .

Diptera: Cecidomyiidae

Ponderosa pine - Galls (*Contarinia* ?) at base of fasicle.

Homoptera: Diaspididae

Sugar pine - *Chionaspis* (*Pheacaspis*) sp. - light infestation - parasitized.

Lepidoptera: Olethreutidae

Ponderosa pine - *Rhyacionia* (*zozana* ?)- light infestation.

Snow Valley - Slight Oxidant Injury

Coleoptera: Scolytidae

1. Jeffrey pine - 12" dbh - *Dendroctonus jeffreyi*.

2. Jeffrey pine - 32" and 22" dbh - old kills by *D. jeffreyi*.

3. Jeffrey pine - 28" dbh - killed by D. jeffreyi - brood recently emerged.

4. White fir - 16" dbh - killed by S. ventralis - emergence has been initiated - some late larvae present.

Lepidoptera: Gelechiidae

Jeffrey pine - very heavy infestation of a needle miner, near Recurvaria milleri.

Homoptera: Diaspididae

Manzanita and Ceanothus - an unknown species of scale was found on both species of plants.

Heart Bar State Park - Very Slight Oxidant Injury

Coleoptera: Scolytidae

1. White fir - 3" dbh ' killed by S. ventralis.

2. Jeffrey pine - 10" dbh - killed by D. jeffreyi - just emerging - many cerambycid larvae present.

3. White fir - 29" dbh ' No. S. ventralis at breast height - many cerambycids.

4. White fir - 18" dbh - Same as for #3.

5. Jeffrey pine - 14" dbh - killed by D. jeffreyi (#53) - new brood adults and emergence holes present.

6. Jeffrey pine - 32" dbh ' old kill by D. jeffreyi.

7. White fir - 22" dbh - same as #3 and #4 - all three look like last year's kill. May be killed by Tetropium abietis or S. ventralis may be present higher in the tree.

8. Mountain mahogany - unknown species of bark beetle.

Lepidoptera: Gelechiidae

Jeffrey pine - moderate infestation of a needle miner near R. milleri.

Homoptera: Diaspididae

Jeffrey pine - Nucalaspsis sp.

Camp Angelus - Moderate Oxidant Injury

Coleoptera - Scolytidae

1. Ponderosa pine - 30" dbh - killed by *D. brevicomis* in 1971.
2. Ponderosa pine - 14" dbh - killed by *D. brevicomis* (#5F) - broo emerged - *D. valens* and resinosus at root crown - *Fomes annosus* sample taken (CA-1).
3. Ponderosa pine - 6" dbh - dead for two years. Killed by flatheaded borers - *F. annosus* sample taken (CA-2).
4. White fir - 10" dbh - dead for longer than one year - killed by *S. ventralis* - round-headed borers present.
5. Ponderosa pine - 10" dbh - killed by *D. brevicomis* - dead longer than one year -termites present - resinosus in roots.
6. Ponderosa pine - 19" dbh - very old kill by *D. brevicomis* - extensive blue-staining.
7. Ponderosa pine - 3" dbh - dead - *Armillaria mellea* and *Polyporus vulvatus* present.
8. Ponderosa pine - 22" dbh - killed by *D. brevicomis* (#2) - brood emerged - *D. valens* in base - basal infection of dwarf mistletoe.
9. Ponderosa pine - 25" dbh - (#3) - basal infection by dwarf mistletoe.
10. White fir - 39" dbh ' no *S. ventralis* at base - flatheaded and roundheaded borers, termites and ambrosia beetles present - dead longer than one year.
11. Ponderosa pine - 13" dbh - killed by *D. brevicomis* and *D. ponderosae* - dead longer than one year.

Damage source unknown.

1. Black oak - branch dieback - extensive on oaks in this plot - a few aphids were found.

General

No *Armillaria mellea* was found in this plot.

Lepidoptera: Arctiidae

White fir - evidence of feeding on the needles by possibly *Halisidota argentata* was abundant - should survey in June to verify.

Barton Flats - Moderate Oxidant Injury

Coleoptera: Scolytidae

1. Ponderosa pine - 6" dbh - dead for longer than 2 years - flatheaded borers present. F. annosus may be present.
2. Jeffrey pine - 16" dbh - dead for longer than 2 years - killed by D. jeffreyi - F. annosus may be present.
3. Jeffrey pine - 16" dbh - dead for one year (#31) - killed by D. jeffreyi - flatheaded borers present. F. annosus may be present.
4. Jeffrey pine - 32" dbh - killed by D. jeffreyi - flatheaded and roundheaded borers, termites, ambrosia beetles present. Also Polyporus vulvatus.
5. Jeffrey pine - several 4" dbh - F. annosus probably present - flatheaded borers and Pityophthorus also present.

General

1. Many types of galls in Quercus chrysalepis.

Sand Canyon - Very Slight Oxidant Injury

Coleoptera: Scolytidae

1. White fir - top killing by S. ventralis.
2. Mountain mahogany - dieback caused by some unknown bark beetle species.

General

1. Mountain mahogany is extensive on this plot.
2. Very little conifer reproduction.
3. No bark beetle activity noted.

Sucking Insects - Survey performed by David J. Voegtlin

The family Aphididae was the main group of sucking insects collected on this survey trip. Collections were made by beating small white fir (Abies concolor) and pine, (Pinus jeffreyi, Pinus ponderosae) as well as lower branches of the larger trees. Collections from each tree were kept separate initially but later aphids of the same species were combined for each plot.

A listing of the species diversity on each of the plots follows:

Oxidant Injury	Plot	No. of Species Present	
Severe	Dogwood	1 sp. on *Abies concolor*	3 spp. on *Pinus ponderosae*
Slight	Snow Valley	2 spp. on *Abies concolor*	2 spp. on *P. jeffreyi*
Very slight	Heart Bar		4 spp. on *P. jeffreyi*
Moderate	Camp Angeles		3 spp. on *P. jeffreyi*
Moderate	Barton Flat		1 sp. on *P. jeffreyi*
Very slight	Sand Canyon	1 sp. on *Abies concolor*	4 spp. on *P. jeffreyi*

A general assessment of aphid abundance was made in each plot. At Snow Valley aphids were very abundant, i.e., easily found and on a number of trees in fairly large numbers. There were fewer aphids at Sand Canyon and Heart Bar but they were not difficult to find. At Dogwood and Barton Flat aphids were very scarce and some species counts were based on one alate female. One species of *Cinara* was found in all cases where collections were made on *Abies concolor*. One elongate needle feeding aphid was common on pine in all plots. Where aphids were present in moderate numbers, in all cases ants were also present. On large clusters of aphids there were often many ants seen among the aphids. At least four species of ants were collected in association with aphids. One ant species was common to all plots and was found tending aphids on both the fir and pines. Parasitized aphids were collected at Dogwood (2 mummies) and several were collected at Snow Valley. All were *Cinara* spp. on pine. More time was spent collecting in these two areas than in the other four.

Predator larvae, Hemerobiidae and Chrysopidae, were fairly common on most plots, also adult Coccinellidae and Neididae were observed. Most aphids collected were on young trees, usually not over ten feet tall. However, it was not possible to sample the upper portions of the large trees. The distribution of these aphids is of interest since it may be related to some of the physical and/or physiological characteristics of the host trees. It is common to find two small trees which are in branch-to-branch contact where one branch will have a large colony of aphids and the other will have none. It is likely that similar plots could be found along the pollution gradient so that parasites and predators of aphids as well as the aphids themselves could be studied and compared.

Summary

This preliminary survey reveals the presence of the key bark beetle species in all plots. A relationship between oxidant injury to ponderosa pine and mortality caused by *Dendroctonus brevicomis* and *D. ponderosae* has been established in previous studies but must be verified in the future on these plots. Also this relationship remains to be established for other conifer species, i.e. sugar pine - *D. ponderosae*, Jeffrey pine - *D. jeffreyi* and white fir - *S. ventralis*. Also the relationship between oxidant injury to mountain mahogany and dieback caused by an unknown Scolytid species is worthy of investigation.

This survey also reveals an abundance of aphids on the principle vegetation. This group of arthropods is of special interest because of their extreme sensitivity to disruptions caused by logging, road building, pesticide application and other activities of man. Oxidant injury to their host plants

may also produce similar changes in their population dynamics.

Other species encountered that may be of interest are the diaspine scales, *Chionaspis* (*Phenacaspis*) and *Nucalaspis*, and the defoliating species on white fir (*Halisidota*) and on Jeffrey pine (*Recurvaria*).

Because this survey was not either extensive or intensive and because observations were not made periodically through the season, further work will be necessary in order to establish a firm observational basis for more intensive study of any possible causal relationships with oxidant injury to the host plants or the insects themselves.